Research Report

Musical Complexity and Cross-Modal Selective Attention: The Effects of Irrelevant Auditory Distractors on a concurrent Reaction-time Task

Josh Chettiar

Student number: 830609

University of the Witwatersrand

MA Research Psychology 2014

Supervisor: Dr. Michael Pitman

Acknowledgements

I would like to foremost thank my supervisor, Dr. Michael Pitman, for his guidance and expertise, without whom this research report would not have been possible, as well as the lecturing staff at the University of the Witwatersrand who made my academic year a challenging yet fulfilling journey.

I would also like to thank my friends and family for their continued support, understanding, and encouragement.

Last, but not least, I would like to dedicate this research to all the musicians, composers, and songwriters who have enriched and inspired my life with their immortal art.

Table of Contents

Acknowledgements i
Table of Contents ii
List of Tables iv
List of Figures v
Abstract 1
Chapter One 2
1.1 Introduction 2
1.2 Literature Review 4
1.2.1 Early vs. late attentional filter 4
1.2.2 Load theory. 5
1.2.3 Dilution theory. 6
1.2.4 Role of working memory load: attention as neural competition. 9
1.2.5 Attentional network task. 10
1.2.6 Cross-modal processing. 12
1.2.7 Musical expectations. 14
1.2.7.1 Metric schematic expectations. 15
1.2.7.2 Pitch-related schematic expectations and melodic organization. 17
1.2.7.3 Atonality and schematic expectations. 20
1.2.8 Musical complexity. 22
1.2.9 Cognitive and physiological effects of music. 23
1.2.9.1 Complexity-arousal hypothesis. 23
1.2.9.2 Compensatory control model. 25
1.2.9.3 Neuronal priming hypothesis. 26
1.3 Research Questions and Hypotheses 27
Chapter Two 29
Method 29
2.1 Sampling. 29
2.2 Participants. 29
2.3 Measures. 30

2.3.1 Pre-test questionnaire. 30
2.3.2 Post-test questionnaire. 30
2.3.3 Attentional network task (ANT). 31
2.4 Design & procedure. 32
2.5 Data. 35
2.6 Data analysis. 35
2.6.1 Reliability and outlier analyses. 35
2.6.2 Descriptive statistics. 36
2.6.3 Repeated measure ANOVAs. 36
2.6.4 Between-subject ANOVA. 36
Chapter Three 37
Results 37
3.1 Reliability analysis. 37
3.2 Outlier analysis. 37
3.3 Gender comparisons. 37
3.4 Post-test questionnaire responses. 38
3.5 Reaction times and errors. 39
3.5.1 ANOVA I: neutral flankers across all music conditions. 41
3.5.2 ANOVA II: congruent flankers across all music conditions. 41
3.5.3 ANOVA III: Incongruent flankers across all music conditions. 42
Chapter Four 45
4.1 Discussion 45
4.2 Limitations and Future Research 48
4.3 Conclusion 49
References 51
Appendices 56
APPENDIX A: Pre-test Questionnaire 56
APPENDIX B: Post-test questionnaire 60
APPENDIX C – Outliers 61

List of Tables

Table 1. Computer terminals and order of auditory stimuli……………………………33

Table 2. Mean RT (milliseconds) across gender groups……………………………...37

Table 3. Post-test questionnaire responses……………………….………………..38

Table 4. Reaction times (milliseconds)…………………………………………………39

Table 5. Error rates (%)………………………………………………………...……40

Table 6. Breakdown of trial errors……………………………………………...……..43

Table 7. Mean RT across no-error trials……………………………….……………..43

List of Figures

Figure 1. Dilution displays..…………………………….…………………………7

Figure 2. Flankers………………………………………………………………...11

Figure 3. Hockey's Compensatory control model..…………………..………………..25

Figure 4. Reaction times (music x flanker conditions)…..…………………………….39

Figure 5. RT means (no errors)…..……………………………………….....……43

Abstract

This study investigates the effects of complex music on concurrent task performance in a response-competition paradigm. Past research in this domain have produced disparate results, ranging from deleterious to facilitative effects. However, such research has failed to account for schematic expectancy violation in its operationalization of melodic complexity. Competing models of cross-modal cognition were therefore evaluated using atonal and tonal musical compositions in a quasi-experimental research design, with response times in the attentional network task (ANT) used to infer whether music had a facilitative or distracting effect on task performance. Participants were recruited from the University of the Witwatersrand's School of Human and Community Development. The computer-based attentional network task (ANT) was administered using the E-prime software, while participants were concurrently exposed to music. Repeated-measure ANOVAs were run to determine whether differences in means attained were significant. The results were consistent with Hockey's (1997) compensatory control model, which predicted faster reaction times during concurrent exposure to complex music due to the activation of a top-down cognitive mechanism which allots greater working memory resources to the primary task. This increase in working memory resources should have led to reduced involuntary attentional switching, thus focused selective attention and enhanced task performance. While the model also predicted a performance-cost tradeoff in the form of physiological distress, self-reported measures of affective and physiological states yielded no statistically significant differences between music conditions. These findings are discussed against a backdrop of past research findings, and recommendations for future studies made accordingly.

Chapter One

1.1 Introduction

Over the last few decades, multimedia access and audio-visual entertainment have become integral to ergonomic design and manufacture of human-machine interfaces. This includes cars with GPS navigation and surround sound, cellular phones, and even select kitchen-appliances that host internet connectivity and social-networking capabilities collectively creating a ‘smart home’ environment (Chan, Esteve, Escriba, & Campo, 2008; Luo, Jin, & Li, 2009) . We are thus immersed in an environment of heterogeneous stimuli that compete for our limited-capacity attentional resources. Some of these competing stimuli require our divided attention, while others take salience in certain contexts and thus require selective attention.

Divided attention has been defined as “the optimal allocation of resources between different sets of input by splitting or rapid shifting of the attentional focus, given the inability to process all available information in parallel” (Hahn, et al., 2008, p. 138). Alternatively, selective attention may be conceptualized as the “focusing [of] resources on specific aspects of input” (Hahn, et al., 2008, p. 138). In both processes, however, competing stimuli may either originate from within or between sensory modalities. Within-modality processing denotes competition between two stimuli within the same sensory modality e.g. visual discrimination tasks with competing on-screen stimuli. If an individual was tasked with tracking certain properties or qualities of both on-screen stimuli, this would be considered an example of divided attention. If, however, the task was to focus on one stimulus and ignore the other, this would be an exemplar of selective attention. A vast amount of research has occurred in the domain of within-modality processing, particularly using Erickson’s Flanker task (Brand-D' Abrescia & Lavie, 2008; Forster & Lavie, 2008; Forster & Lavie, 2011)

Alternatively, cross-modality processing refers to stimuli competing for attention from disparate sensory modes e.g. auditory commands and visual cues (Brand-D' Abrescia & Lavie, 2008). Here, if an individual was tasked with encoding auditory-verbal commands over a phone or headset while simultaneously encoding visual information on a computer screen, this would be considered an act of divided attention. Conversely, if tasked with ignoring the auditory-verbal commands while attempting to encode the visual information, this would be instead an act of selective attention.

Since the current study focuses on visual attention in the context of an irrelevant auditory distractor, the forthcoming literature review will concentrate on selective attentional mechanisms and theories, although both within-modality and cross-modality processes will be discussed in this regard. The relationship between working memory, musical complexity, and concurrent task performance has been inferred through previous research (Arkes, Rettig, & Scourgale, 1986), where participants indicated a preference for 'simple music' when engaging in high-load tasks. However, the definition of musical complexity used here, as well as in research on the topic in general, may be critiqued for having an incongruence with the more stringent definition afforded the term by musical-cognitive theorists (Shmulevich & Povel, 2000) who highlight the role of hierarchical structure (polyphony), and amount of dynamic information embedded within the stream, and the extent to which it violates listener expectations (Eerola, 2003; Huron, 2007).

Research by Furnham & Allass (1999) for instance used music by Michael Jackson and Alice Cooper in their 'complex music' condition in their investigation on the effects of musical complexity on cognitive performance, concluding that listening to complex music facilitated the performance of extroverts on memory recall, but not that of introverts. Such musical compositions, however, remain only minimally complex in relation to genres such as free jazz, experimental metal, and the expressionist movement of early 20th century classical music, and violate few if any schematic and dynamic musical expectations.

Furthermore, research on the effect of background music in general on task performance have produced mixed results, showing both facilitative (Rauscher, Shaw, & Ky, 1995; Rickard, Toukhsati, & Field, 2005; Ünal, Steg, & Epstude, 2012), as well as distracting effects (Arkes, Rettig, & Scourgale, 1986; Brodsky, 2002; North & Hargreaves, 1999). Therefore, this research study aims at testing specific forms of these competing hypotheses within a quasi-experimental setting by investigating the effects of complex atonal music on a concurrent reaction-time task. This will be achieved by first reviewing the literature on selective attention and cross-modal interference, before moving on to music processing and schematic expectations of musical events, as well as the mechanisms by which background music may affect concurrent task performance. The findings of the current study will therefore be evaluated against Konecni's model of music cognition (1982), which stresses the distracting effect of music on task performance through additional attentional processing demands, and Hockey's compensatory control model (1997), which predicts a facilitative effect of music on task performance through a shift in cognitive strategy to an active control mechanism that temporarily increases working memory resources at the cost of increased autonomic/physiological distress.

1.2 Literature Review

1.2.1 Early vs. late attentional filter

Following Broadbent's (1958) suggestion of a limited cognitive pool of attentional resources via his Filter theory, a debate between scholars occurred in regard to the exact position of the filter (or 'selector') itself in the attentional process. Broadbent's (1958) original theory specified an early filter, with a small amount of information being selected among many in the early stages of the attentional process prior to semantic identification. In opposition to this were late-filter theories which proposed that such an attentional filter only existed after the semantic stage, or meaning-making stage, of stimuli-identification (Deutsch & Deutsch, 1963). Accordingly, all information, regardless of salience or listener-intention, is attended to and processed for meaning. Thereafter, information low in semantic-importance or relevance is discarded, while relevant information is processed at subsequent higher-order (and conscious) stages of the process. Evidence for a late-filter was found in an experiment by Cherry (1953) that established a phenomenon later referred to as the cocktail party effect, whereby the mention of one's name has a high likelihood of attracting one's attention despite being embedded in a cacophony of noise and competing verbal stimuli. This phenomenon would not occur if all information will filtered prior to semantic processing (Deutsch & Deutsch, 1963).

In an early attempt to reconcile these competing theories, Treisman (1969) advocated for a reconceptualization of the attentional filter. According to her theory, the filter actually functions more as an attentional attenuator. Thus, unattended information is not filtered out but rather attenuated, representing weaker signals that are fed to the second stage of the process along with stronger signals that represent the attended information.

Normatively, these weaker signals are too weak to sufficiently activate attention and orientation processes. Some stimuli, however, have a low threshold of activation, allowing for sufficient identification even if they are attenuated. This explains the cocktail party effect, as one's name holds special salience and thus is of a lower threshold for identification than other unattended information in the stream (Driver, 2001).

1.2.2 Load theory.

More recent research, particularly the work of Lavie (1995), has proposed alternate mechanisms describing the attentional process. By using the flanker task, Lavie demonstrates the role of perceptual load on distractor interference. This work led to the generation of what is referred to as Lavie's load theory. In the Flanker Task (Forster & Lavie, 2008), participants are required to attend to a fixed location on a computer screen and make timeous appropriate motor responses by pressing a specific key or button in front of them in accordance with the pre-specified rules. Thus in a typical setting, a participant would be required to press the 'X' key if the presented stimuli is either a 'P' or 'J' symbol, or the 'M' key if the symbol is an 'R' or 'F'. On either side of the presented stimuli ,however, are various 'distractor' symbols that are often referred to as being "task irrelevant", as they have no impact upon the likelihood or position of the salient presented stimulus/symbol.

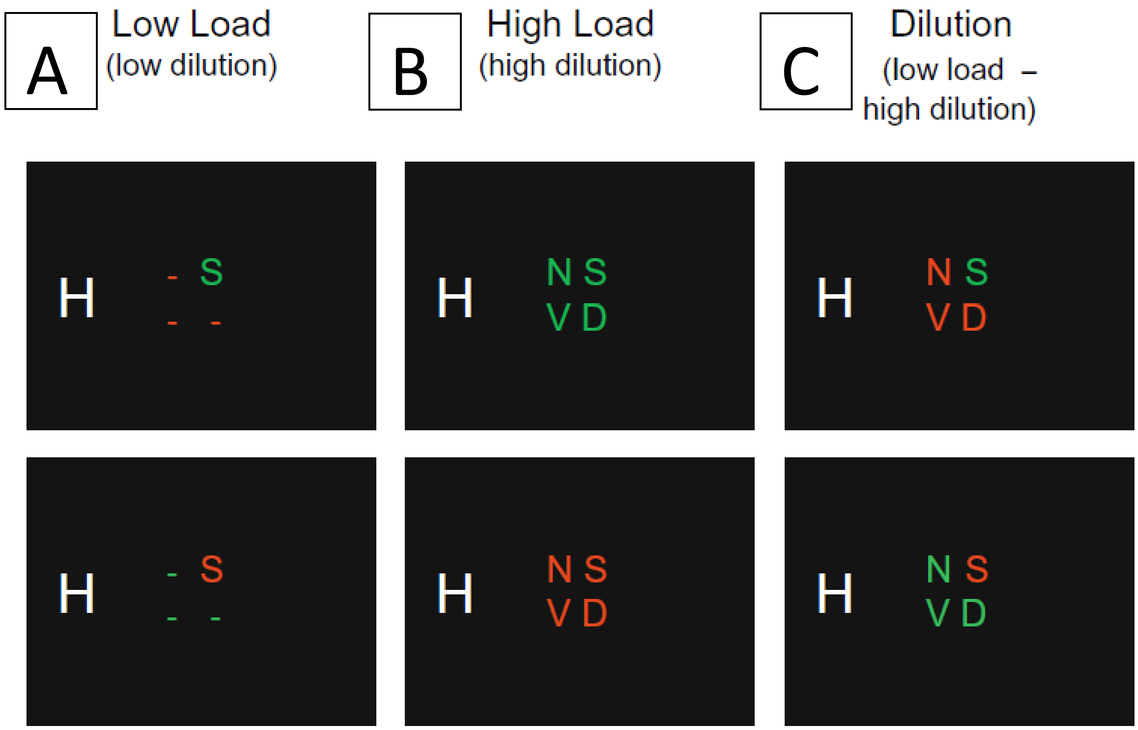
The presence of these distractors nevertheless results in a slower/delayed response time to the primary task (Lavie, 1995). Researchers infer from this phenomenon the processing of these task-irrelevant distractors despite their absence of salience. The effects of the distractors, however, are minimized if the perceptual load of the task is increased e.g. made more difficult through an increased stimulus/symbol-set on the computer screen. Lavie (1995) thus developed her Perceptual Load Theory to explain this phenomenon, which posits that if the perceptual load of a given task is low, it only requires a small amount of cognitive resources, thus leaving the rest of these resources free to 'spill over' and attend to the irrelevant distractors. If the perceptual task is made more difficult, however, more cognitive resources are needed to attend to the primary task, leaving little to no 'left-over' resources available to process the irrelevant distractors. Therefore, since the irrelevant distractors are not being processed, they do not impact on reaction time.

Stated in the terminology used in regard to the early vs. late selection models of attention, load theory would predict early selection for high load conditions, but late selection for low load conditions (Lee & Choo, 2013).

1.2.3 Dilution theory.

However, there exist competing explanatory theories for this facilitative effect through an increased task load, such as that of Benoni & Tsal's (2010) Dilution theory. According to Dilution theory, the relative disappearance of reaction-time costs under the high-load condition is not due to a lack of excess attentional resources (from there being no "left-over" resources), but rather due to the flankers being diluted by the increased stimulus-set on the screen in the high load conditions. Stated differently, because the low-load condition contains a smaller display set, usually just the target and a distractor, the latter more strongly "activates the target-opposite response category [i.e. the primed cognitive-motor response associated with the direction of the arrow, or with the other letter, opposite to that of one currently displayed] thereby delaying response to the target" (Benoni & Tsal, 2010, p. 1293). The high-load condition, on the contrary, by virtue of containing a larger stimulus-set, contains a greater number of neutral stimuli within which the distractor is embedded. Therefore, a dilution effect is created in which the visual representation of the distractor is degraded by the nearby and lexically similar neutral stimuli, leading to an insufficient activation of the target-opposite response category. This manifests in less distraction, and faster reaction times compared to the low-load condition. Figure 1 illustrates this concept, with low-load and high-load display sets shown.

Figure 1[1] – Dilution displays



In the above figure, varying load/dilution displays are illustrated using both green (top-most horizontal series of displays) and red examples (bottom-most horizontal series of displays) respectively. Participants were instructed to press one button if the target letter (the largest letter in white) was an H (in what may be called response category 1), and another button if the target was an S (response category 2).

In 1A, the display is low in perceptual load since it contains only one target and one distractor, with the latter clearly distinguishable (a "popping out" effect) due to the absence of any other neutral stimuli. Response competition is generated by way of the target (H) and the distractor (S) belonging to separate response categories. However, this response competition is amplified by the fact that this display is low in dilution i.e. the distractor is highly salient by virtue of being the only letter in the display beside that of the target. In the high load condition (1B), however, the response competition is reduced due to the distractor (S) being "diluted" or deeply embedded among neutral yet homogenous (all green in the top example, all red in the bottom) letters. The result is of course faster

[1] Adapted from Benoni & Tsal (2010)

response times in 1B (high dilution) due to less response competition, in comparison with the low dilution (1A) condition.

In 1C, Benoni & Tsal (2010) show how it may be possible to achieve a low load yet high dilution display. Here, the distractor associated with the competing response category (‘S’) is embedded among various neutral stimuli (thus diluted), yet remains distinguishable from them, and the target, due to a difference in color (similar to the low-load condition). This allowed for a testing of rival hypotheses, since according to Lavie’s load theory, figure 1C should lead to slower reaction times, since the salience of the distractor is high (i.e. it ‘pops out’ due to the obvious color difference, thus activating the target-opposite response category) in this low load condition. However, Dilution theory predicts faster reaction-times comparable to a high-load condition, in which the distraction effect is nullified due to a highly diluted distractor, as it is embedded among neutral letters. In Benoni & Tsal’s (2010) research, the latter hypothesis was confirmed. Thus, according to Benoni & Tsal (2010), this dilution of the distractor within a display is responsible for the improved task performance under conditions of high perceptual load, and not the lack of excess cognitive resources to process these distractors.

Additionally, critique has been levelled against the extent to which such distractors may be justly called “task irrelevant”, given that they share structural features with the relevant stimuli (Buetti, Lleras, & Moore, 2014). In other words, both the irrelevant stimuli and relevant stimuli belong to the same symbolic-lexical set in addition to sharing other structural properties such as size, color, hue, etc. A truly operational, and ecologically-valid, irrelevant stimulus would then belong to a different set and share little to no structural features with that of the relevant stimulus. Unto this end, Forster & Lavie (2011) attempted to use flashing images of cartoon superheroes in a novel capture task which satisfied the criteria of being an irrelevant stimulus in the context of the experiment. The results show that the presence of these fleeting image-distractors slowed participant response times during low-load condition, but to a significantly lesser degree in the high-load condition. Lavie & Forster (2011) locate these findings with regard to real-world scenarios, such as the presence of large billboards on the side of roads which, although being irrelevant to the task of successful driving and navigation, nevertheless may deplete attentional resources and slow down reaction time to salient environmental features such as road hazards or other motor vehicles under conditions of low-load, e.g. monotonous driving conditions.

1.2.4 Role of working memory load: attention as neural competition.

In an attempt to reconcile elements of both load theory and dilution theory, Scalf, Torralbo, Tapia, & Beck (2013) formulated a third alternative to explain the observed phenomenon of reduced distraction effects under high load (or high dilution) conditions. According to this theory, competition for neural representation in the visual cortices and higher-order convergence areas is responsible for the phenomenon. Under conditions of high-load, there is a greater competition between spatially proximal stimuli for neural representation. Thus, a top-down mechanism is activated in order to compensate for this under-representation of salient stimuli by either enhancing them and/or diminishing the salience of irrelevant distractors. The result is less distraction under high-load conditions as compared with low load conditions, and thus faster reaction times. This top-down mechanism is also referred to as a “frontoparietal mechanism” (Scalf, Torralbo, Tapia, & Beck, 2013, p. 6).

This mechanism has been operationalized using different terminology in other literature on attention, most importantly as working memory involved in the suppression of involuntary orientation to the irrelevant and distracting auditory stimuli (Berti & Schroger, 2003; King & Kutas, 1995; Marini, Chelazzi, & Maravita, 2013; Taylor, Lindsay, & Forbes, 1967). As in the literature describing a frontoparietal mechanism, this is achieved through a top-down inhibition by the central executive or supramodal mechanism. Interestingly, when external distraction is anticipated but absent, a degradation of performance on the primary task occurs due to the use of resources to unnecessarily maintain activation of the top-down mechanism when unneeded (Marini, Chelazzi, & Maravita, 2013).

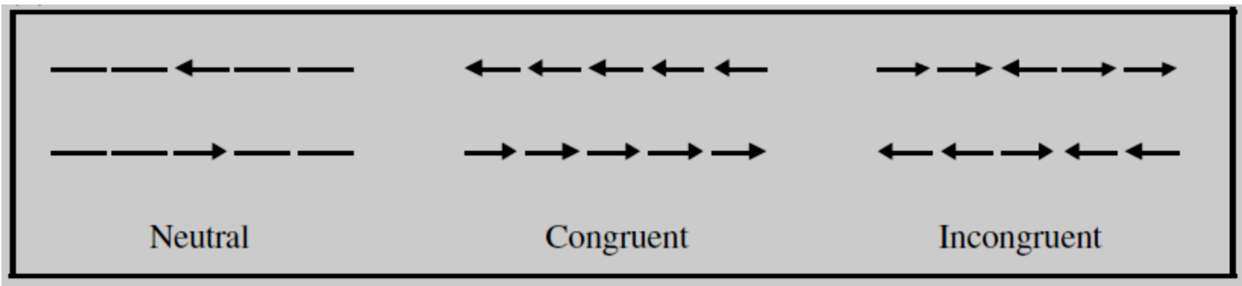
In a study by Berti & Schroger (2003), the role of working memory in a preattentive syntactical parsing process was investigated in an auditory distraction paradigm. Syntactic parsing refers to an analysis of components in a string (such as a sentence or musical phrase) in accordance with internalized rules (grammar, syntax etc.) (Koopman, Sportiche, & Stabler, 2003). Accordingly, attentional processes monitor the environment for stimuli, flagging those that are incongruent with these internalized rules of expectations as salient. The results of Berti and Schroger's study (2003) add support to previous findings that deviant information is both processed and potentially impairs performance on the primary task. This distraction effect is, however, attenuated in the high load conditions. The researchers conclude that this was so due to working memory controlling the involuntary attention switcher in the high load conditions in a top-down manner, leading to a smaller reaction-time cost vs. the low load condition. This mirrors the evidence previously accounted for above for a supramodal/frontoparietal mechanism that operates in a top-down manner to coordinate distractor interference.

Similarly, while Lavie's (1995) theory of perceptual load described a passive process of diminished distractor interference, a more active process involves the direct and active involvement of the executive control, a frontal cortex mechanism (Brand-D' Abrescia & Lavie, 2008). Here, the executive control is responsible for the maintenance of salient stimulus priorities, and thus "minimizes distraction by low-priority task-irrelevant stimulus even when these have been perceived" (Brand-D' Abrescia & Lavie, 2008, p. 508). What this implies is that, under conditions of high executive load (as opposed to perceptual load), there should be greater distractor interference effects due to an impaired ability on behalf of the executive control to minimize distractor awareness, since it is finite in resources.

1.2.5 Attentional network task.

The Attentional Network task (ANT) was developed by Fan, McCandliss, Sommer, Raz, & Posner (2002) to evaluate three interrelated attentional network systems (alerting, orienting, and executive control) using a combination of the cued response and flanker tasks. The participant is momentarily provided an on-screen stimulus in the form of arrows, with the task of pressing the appropriate mouse key in response to the direction of the central arrow only. Surrounding the central arrow however may be distractors in various states: neutral distractors, which are horizontal lines, congruent distractors, which are arrows pointing in the same direction as that of the central arrow, and incongruent distractors, which are a combination of arrows pointing in both directions at either side of the central arrow. The string of arrows always appear either below or above a central fixation dot. Figure 2 represents an illustration of the flanker types.

Figure 2[2] *– Flankers*



The task operates within the response-competition paradigm, such that task difficulty is a function of the degree of cognitive competition between primed responses. After the establishment of primed responses to right and left-pointing arrows respectively, the flanking of one target class (e.g. a right-facing arrow) by an item from a competing target-class (e.g. a left-facing arrow) results in response competition, which numerous studies have shown to lead to a general increase in reaction time responses (Driver, 2001). This situation is offered in the incongruent flanker trials, where response competition results in a more difficult task. In comparison, the neutral flanker trials contain no response competition, as the salient target (central arrow) is alone. For the congruent trials, the flankers point in the same direction as the salient target, thus response competition is also absent.

In a study by De Fockert and Leiser (2014), high contrast irrelevant flankers were shown to facilitate rather than impede on mean reaction times when they were collinear (i.e. arrows pointing in the same direction as the low contrast central target arrow) under conditions of high working memory load. The authors attributed this effect to greater flanker processing under conditions of high working memory load due to taxation of the top-down central executive that suppresses non-salient stimuli. In the ANT task, however,

[2] Adapted from Fan et. al (2002).

there is no difference in contrast between target and flankers, and so it is uncertain whether this facilitative effect will occur under the congruent flanker condition.

Although not of focus in this present study, the ANT task combines the stimulus-based reaction time task described above with a variety of cues on a trial-by-trial basis. The cue is in a form of an asterisk symbol that appears at a variable position relative to the central fixation dot on a trial-by-trial basis. The cue thus functions to provide additional information pertaining to the exact position of the forthcoming stimulus (central arrow), as the possibility is ambiguously fixed between two locations (above or below fixation) by default. These cue-states include there being no cue, thus providing no information at all, a center cue, which provides minimal additional information (only that the stimulus is forthcoming, but not where), a double cue, which again provides minimal additional information, and finally spatial cues (either above fixation or below fixation). This latter cue provides maximum information as to the position of the forthcoming stimulus. Since these cueing conditions are necessary for evaluating the alerting and orientating networks, but not the executive network, it did not form part of the present study's analysis, as instead responses to flanker types were summed across cueing conditions, as is the case when evaluating the executive network alone (Fan, McCandliss, Sommer, Raz, & Posner, 2002).

1.2.6 Cross-modal processing.

In contrast to the traditional flanker task referred to above, cross-modal processing refers to competing stimuli from different sensory modalities, for instance between an auditory signal and a visual stimulus or tactile sensation (Brand-D' Abrescia & Lavie, 2008). In early research conducted on cross-modal processing there were disagreements regarding whether there exist sensory-specific attentional systems without any overlap between them (such that it would be unlikely for a visual stimulus to intrude upon the resources needed to process an auditory signal), or whether there exists a central mechanism, such as the supramodal/frontoparietal mechanism specified above, that overlaps between these sensory modalities and is responsible for their respective resource allocation (Lindsay, Taylor, & Forbes, 1968). Specifically, one side argued in support of simultaneous task performance between modalities as having no cost to attention, as reaction times here were not significantly different to the reaction times when performing the tasks alone in either modality (Lindsay, Taylor, & Forbes, 1968). This, however, was not supported in other studies that showed a single-channel attention system, wherein a central processor with finite and limited attention is fed incoming information in series. Since we are often confronted with simultaneous stimuli, however, loss of information occurs when some information is processed at the cost of others. Recent experimental evidence suggests that the latter may be true, whereby a robust supramodal mechanism filters stimuli both within and across sensory modalities (Bonnel & Hafter, 1998; Marini, Chelazzi, & Maravita, 2013).

While most of the research conducted within selective attention centers on dual-task performance within a visual modality (Buetti, Lleras, & Moore, 2014; Forster & Lavie, 2011; Forster & Lavie, 2008; Lavie, 1995; Scalf, Torralbo, Tapia, & Beck, 2013), there exists significant inquiries into auditory processing, especially those inclusive of the use of EEG and fMRI tools. A pertinent discovery made through EEG measurements during listening tasks point to a specific event-potential that is elicited in participants when attending (either consciously or unconsciously) to an auditory stimulus that violates schematic or dynamic expectations (Koelsch, et al., 2001).

By measuring the electrical activity generated within the brain via several techniques, such as electroencephalography (EEG), it is possible to detect dynamic responses, or event-related potentials (ERP), to environmental stimuli. These potentials may be analyzed in regard to their amplitude, frequency, latency and so forth (Villarreal, Brattico, Leino, Ostergaard, & Vuust, 2011). Various specific ERP's have been found to be elicited in response to deviant auditory stimuli. Some of these include a late positive potential (P300), mismatch negativities (MMN), and early right-anterior negativity (ERAN) (Eerola, 2003). The ERAN response in particular is elicited by violations of schematic and dynamic expectations (Hahne & Friederici, 1999; Villarreal, Brattico, Leino, Ostergaard, & Vuust, 2011) which furthermore signifies a syntactic parsing error. Although originally intended to describe language processing, research by Koelsch, Maess, & Friederici (2000) indicate that there is an overlap between the syntactical processing of language and music syntax.

Important here is that although the amplitude of the ERAN is much larger when consciously attending to deviant musical stimuli (Loui, Grent-'t-Jong, Torpey, & Woldorff, 2005), it is still present when participants were specifically given instructions to not attend to the musical stimuli, but to rather focus exclusively on the visual task provided (Koelsch, Schroger, & Gunter, 2002). This provides evidence for what the authors refer to as a preattentive syntactical parsing process that occurs unconsciously even if not selectively attending to the auditory stream. This process may indeed have evolutionary origins and adaptive benefits, as passive monitoring of unattended auditory streams for deviancy allows for the detection of potential danger.

Syntactical parsing failures in music-listening are relating to schematic structures developed through a culturally-relative statistical learning process under conditions of frequent exposure (Huron, 2007). In a musical context, there are certain metrical (time-structured) and harmonic (pitch-structured) standards upon which listener-expectations are coded.

1.2.7 Musical expectations.

Tuomas Eerola (2003) defines expectations as “hypotheses about the configurations underlying the real world” (p. 18). Formulating, storing, and retrieving these expectations represent an evolutionary adaptive design that allows for the efficient interpretation of and appropriate response-action to environmental stimuli. The mental processes that underlie such expectations are what is referred to as cognitive schemata, or schemas for short. These are mental blueprints that categorize incoming stimuli as pre-defined thematic content (Kibler, 2011). This allows for a speed of processing that is far more efficient than if we were to analyze every bit of information embedded in a stimulus and then construct a unique and new response-category. Thus, schemas allows for an adaptive and speeded response to environmental stimuli as well as the conservation of mental resources.

According to Narmour (1991), expectations may be divided between data-driven and schema-driven expectations. Data-driven expectations follow a bottom-up sensory process in which basic principles of perceptual organization aid the interpretation and anticipation of environmental stimuli. For instance, the gestalt principle of proximity, when applied to auditory stimuli, would describe the process through which several tones are grouped or perceived together as a whole due to “pitch proximity and temporal contiguity” (Eerola, 2003, p. 19), as well as source convergence (i.e. the tones sharing a common spatial source), as opposed to being perceived as several disparate stimuli.

If particular data-driven expectations, or heuristic strategies, are successful in anticipating some future outcome, they may be transferred to long-term memory, where it becomes known as schema-driven expectations (Eerola, Louhivuori, & Lebake, 2009). Schema-driven expectations are thus formed from frequent exposure, operant conditioning, and enculturation, via a statistical learning process. Narmour (1991) proposes that musical expectations are formed on the basis of these two complimentary processes, which explains the near-universal properties of music that then, over a culture’s collective history, undergo variation and selection, ultimately resulting in the multitude of styles and genres present today. Once embedded in cognition, musical expectations become fundamentally linked to listener enjoyment, both in the fulfillment of expected musical outcomes, but also in its delay and omittance (Huron, 2007).

1.2.7.1 Metric schematic expectations.

Metric expectations refer to expectations that listeners form in regard to *when* a sound, or auditory stimulus, should present itself (Huron, 2007). This may extend beyond music, for instance the expectation for a sound to follow immediately after one throws a ball against a wall, for instance. This expectation may be precise, such as in the example above, or imprecise. An imprecise metric expectation would be anticipating the onset of the sound of thunder immediately following a lightning strike. Since the timing may be of variable length, depending on the distance between the observer and the lightning strike, this sort of expectation is inherently imprecise, but not entirely unpredictable.

In music, a *tactus* exists that represents the basic beat or periodic pulse in a passage of music (Huron, 2007). This coincides with the timing of a spontaneous “tapping” which a listener may engage in response to the music. This unconscious and spontaneous tracking of such a metric property of music is of evolutionary origin and is highly adaptive, since the successful anticipation and prediction of the onset of stimuli in the environment leads to better management of our arousal levels, such that we may conserve energy by not remaining chronically aroused through the full duration of the stimulus (Huron, 2007). Furthermore, it allows the supramodal top-down mechanism previously described to become only periodically activated, as opposed to chronically activated (with the latter resulting in considerable depletion of attentional resources in response to a potentially harmless environmental stimulus) (Huron, 2007).

In most forms of Western music, the attention of listeners is strongly drawn towards the presumed downbeat in a passage of music. This was experimentally verified by Jones, Moynihan, MacKenzie, & Puente (2002) by exposing participants to an initial tone, eight distractor (irrelevant) tones, and a comparison tone. Participants had to signal whether the comparison tone was of higher or lower pitch than the initial tone. However, the position of the comparison tone was varied along the bar of music, such that it sometimes fell on the downbeat, while at other times it fell before (earlier than) or after (later than) the downbeat. The results indicate that the pitch-comparison abilities of participants were significantly affected by the position of the comparison tone, such that responses were more accurate when the tone fell on the downbeat than when it was before or after it. The researchers thus concluded that the attention of western listeners are drawn to the downbeats in passages of music as a default and as a result of a statistical learning process through frequent exposure. This is further supported by a study by Palmer & Krumhansl (1990) who found that participants expected musical events to occur at the stronger beats of the bar as opposed to the off-beats.

In addition to where a tone falls without a given passage of music, the basic encompassing structure of the passage is salient to listeners. In the Western Classical tradition in particular, simple binary duple meter (e.g. 2/4), triple meter (e.g. 3/4), and quadruple meter (e.g. 4/4) are the most commonly occurring, according to a survey containing a sample of several thousand classical pieces (Huron, 2007). Pieces with irregular meter (e.g. 7/8, 5/4) accounted for only 0.8% of the total sample, compared to 32% accounted for by simple triple meter. Indeed, an experiment investigating listener meter-preference found that a significant proportion of participants were "subjectively accenting the odd-numbered events" (Huron, 2007, p. 195) in a sequence of tones that were identical (i.e. without any accents in the stimuli itself). What this means is that listeners were projecting a binary meter onto the sequence of tones as a result of a schematic default. This confirms the statistical learning process model, as these schematic defaults coincide with the most commonly occurring meter in western classical music as described above.

However, the activation of these particular schemas is contextual. For instance, Reggae places emphasis on the off-beat as opposed to the downbeat as part of its standard repertoire. Therefore, it may be that listeners construct genre- or style-dependent schematic metrical expectations that are contextually activated.

When such heuristics employed by listeners result in a successful prediction of an event (e.g. a tone does indeed fall on the downbeat, or the passage conforms to simple duple meter in accordance with the metric schemata of the listener), there is a positive prediction response that serves to reward and reinforce the use of the heuristic strategy. This positive emotion, according to Huron (2007) is misattributed to the stimulus itself (the prediction effect), resulting in positive feelings towards the source (the music). However, if the prediction is unsuccessful, such that the tone did not in fact fall on the downbeat, then either a negative emotion or a contrastive positive emotion of surprise may arise. Which of the two is triggered may be a factor of the degree of schematic violation or the extent to which such a violation occurs, as well as prior exposure to the particular form or passage of music.

1.2.7.2 Pitch-related schematic expectations and melodic organization.

In addition to when a tone is expected to occur within a passage of music, there exist expectations pertaining to what type of tone is to occur under both static and dynamic conditions. With regard to the former, Huron (2007) sought to investigate whether there existed a link between absolute pitch and the frequency of occurrence of those pitches. Absolute pitch refers to the ability of an individual to name and identify an isolated pitch without any other note or external reference. This phenomenon is extremely rare, with less than one in a thousand musically inclined individuals capable of this feat (Huron, 2007). However, it has been previously shown that a sample of individuals with absolute pitch were quicker in identifying some pitches (C and G) than others (E and B) (Huron, 2007). Huron analyzed a large sample of western music and found that the most frequently occurring pitches were indeed those that participants were quicker in identifying in the previous study. This was explained using the Hick-Hyman law, which posits that speed of processing is related to frequency of exposure.

In a connected study, Huron (2007) found that listeners were quicker in imagining an isolated tone as representing the first note in a melody as the tonic (first scale degree, *do*), followed by the dominant (fifth scale degree, *so*), as opposed to the supertonic (second scale degree, *re*) and subdominant (fourth scale degree, *fa*). In other words, participants responded quicker when they treated the isolated tone as the first and fifth scale degrees of a diatonic scale. Again, Huron found that the first and fifth scale degrees do indeed occur more often as the first note in a melody in western music than the second and fourth tones. If the statistical learning model is to be put forth, then it would stand to reason that since western listeners are frequently exposed to certain pitches and scale degrees and less exposed to others, expectations are developed in the form of pitch-related schemata in line with this prior exposure.

In a follow up study, Huron (2007) asked participants to spontaneously imagine a single pitch without singing it or producing it any way. Probe tones were then used to isolate the imagined pitch. Results of the investigation show that the most commonly spontaneously imagined tone was near F4 (F above middle C). This was only two semitones away from the most commonly occurring pitch in western music (E♭4). Huron reasons that this lends support to the argument that musical expectations are developed through a statistical learning process.

In regard to other pitch-related musical expectations, or such expectations that function in a series of tones as opposed to a single static tone, there exist what are referred to as contingent frequencies (Narmour, 1991). This involves the expectation that a subsequent pitch will be of a certain distance from a prior pitch in the string. In other words, “given pitch X, the probability of pitch Y is high, but the probability of pitch Z is low, and so on” (Huron, 2007, p. 70). This concept received its first major investigation through Narmour (1991), who developed the implication-realization model to explain this particular musical expectation, furthermore receiving empirical validation by Schellenberg (1996).

Using statistical analyses on participant responses, Huron (2007) was able to compute the probabilities of successive pitches given a particular pitch as an antecedent state. In a related study, it was found that melodies in real-world western music favour small intervals over large leaps between pitches. Exceptions to this are the Scandinavian and Swiss yodeling forms of indigenous music that employ larger intervals. This tendency probably evolved through efficiency and ease of production, since it is easier to play or sing two notes that are close to each other as opposed to notes with a wider interval. Given that listeners have been found to process music with smaller intervals more efficiently (Deutsch, 1978 as cited in Huron, 2007), it would be reasonable to infer that the Hick-Hyman law should hold true here too i.e. there exists a link between frequency of exposure to the use of smaller intervals and the development of pitch-related schematic expectations. Bharucha (1996) extends this contingency principle to chord harmonies with his notion of melodic anchoring, which refers to the expectation among listeners for unstable pitches to gravitate towards stable pitches in a given key. This is based upon a schema relating to a "hierarchy of harmonic stability" (Koelsch, Schroger, & Gunter, 2002, p. 38).

Using a concept developed by Paul von Hippel (2002), Huron described another pitch-related expectation called step inertia, which describes the tendency for "small pitch intervals to be followed by pitches that continue in the same direction" (Huron, 2007, p. 77). Evidence supporting this phenomenon comes from both experimental studies and secondary analysis of pre-existing compositions from across several cultures. In regard to the latter, Von Hippel found that step inertia was indeed a regular occurrence, but only for descending steps i.e. "70% of descending steps are followed by another descending interval" (Huron, 2007, p. 77), while for ascending steps no such trend is evident, with it being equally as likely to be followed by an ascending interval as it is by a descending interval. However, subsequent experimental findings by Von Hippel, as detailed by Huron (2007), point to step inertia in both descending and ascending steps. Here, participants were exposed to series of randomly generated twelve-tone rows (that is, all twelve pitches of the diatonic scale) and asked on each occasion to state the note they expected to follow in the passage (the hypothetical 13th note). Participant responses were judged according to whether the note they chose continued in the direction of the interval formed by the last two notes of the passage (step inertia), or whether it reversed direction (violating the assumptions of step inertia). Results indicated expectations of step inertia for instances where the antecedent intervals were both descending and ascending, respectively.

While the phenomenon of step inertia applies only to small pitch intervals, there also exists schematic expectations of what should follow large pitch intervals. This Huron (2007) refers to as the post-skip reversal phenomenon. Here, large scale intervals are more likely to be followed by a change in direction towards the tonal center. This was confirmed by a follow up study mentioned by Huron (2007), where listeners' expectations were found to follow the post-skip reversal phenomenon.

Lastly, the melodic arch (tendency for melodies to rise, peak, then decline to form an arch-shaped contour) is yet another pitch-related schematic expectation, although not all melodies follow this tendency. According to an analysis carried out by Huron (2007) on over ten thousand musical phrases, about 40% of them followed the melodic arch principle. Evidence for such a principle being incorporated into listeners' expectations are ambiguous however, with a study by Bret Aarden, mentioned in Huron (2007), finding mixed results of preferential melodic contour at the beginning and ending of phrases respectively. Boltz (1993), however, found clear expectations on behalf of his sample of western listeners in regard to phrase structure, with pitch-related irregularities detected more often when they occurred at the beginning or end of phrases than anywhere else in the phrase.

1.2.7.3 Atonality and schematic expectations.

Atonal music is a label attached to an early twentieth century music form within the western classical tradition. While tonal music has a definitive key and tonal center, atonal music on the other hand attempts to free itself from tonality by abandoning such a tonal center (Friedheim, 1966; Schellenberg, 1996). Although he rejected the label 'atonal', Arnold Schoenberg effectively pioneered the style using a compositional approach or method referred to as the twelve-tone row. Here, all twelve tones of the diatonic scale are afforded equal frequency within a piece of music, resulting in tonal ambiguity.

Theoretically, however, while the whole may lack a tonal center, there exists local key implications in which sections of the music are less tonally ambiguous than others. Huron (2007) showed this by constructing twelve-tone rows than have local key implications, such that the first bar implies a pentatonic minor for instance, while the next bar a major, and so forth, all within the confines of giving each pitch equal precedence. In order to ascertain whether such local key implications were present in Schoenberg's compositions, he then compared a total of 42 twelve-tone rows developed by Schoenberg to self-generated controls that had local key implications. Results indicated that Schoenberg's music has far lesser a degree of local key implications than the controls. This shows insight on behalf of Schoenberg, who was both aware of and premeditatedly attempted to move away from key implications not just at the global level but at the local level as well.

Some, like Huron (2007), thus prefer to use the term contratonal to atonal, since local key implications are not entirely absent, just significantly reduced, both in comparison to tonal music (severely so) and in comparison to other twelve-tone row music. This tendency in Schoenberg's music is just one example, albeit a major one given the emphasis on tonality in western music, of a schematic expectation violation. Another one is his use of larger than conventional melodic intervals, which were "more than double the average for music from around the world" (Huron, 2007, p. 344). Likewise, Schoenberg violated several metric expectations in his music. His piece *Erwartung* for instance contains "426 bars literally without thematic repetition" (Friedheim, 1966, p. 67) in addition to having "at least nine changes of meter and sixteen changes of tempo" ((Friedheim, 1966, p. 67)).

Given the breadth at which Schoenberg violated listener expectations, complete predictive failure occurs when a typical listener approaches his music using as a framework the conventional pitch-related and metric-related schemata detailed above (Huron, 2007). Indeed, in an experiment by Schellenberg (1996), pitch-related predictions of atonal musical passages were largely incorrect, reflecting predictive failure when applying tonally-derived schematic expectations to atonal music. The result of such predictive failure is a misattribution of the feelings of discomfort and agitation to the music itself (Huron, 2007). It is no surprise then than Schoenberg's music was, and still is, viewed as largely inaccessible to the typical western listener.

1.2.8 Musical complexity.

Several models exist for classifying and measuring musical complexity. While rigorous and precise, they have been underutilized in cognitive research on musical processing and perception. Pressing (n.d.) posits a notion he refers to as hierarchical complexity. Here, the number of elements (or information as may be measured in bits) embedded within a musical passage increases in relation to the number of structures or levels it contains e.g. three voices in counterpoint to one another. This can be taken further, as in imitative counterpoint, where voices may remain harmonically interdependent yet vary in time of onset or contour, such that one voice may enter late or early in relation to another voice and/or with the melody sounded backwards. This creates a "polymetric multiplicity" (Pressing, n.d., p. 2), with each simultaneous layer resisting Gestalt organization. Therefore, one may say then that West African drumming is more complex than Punk Rock drumming due to the greater hierarchically-ordered structural properties of the former.

Pressing (n.d.) likewise identifies dynamic complexity, which refers to the degrees of stationarity in a system over a fixed amount of time. Musical passages that show the greater amount of harmonic, melodic, and rhythmic change over their duration may be judged to be more complex than passages with a highly stationary or periodic movement. The latter is considered a hallmark of modern popular music where simple forms like A-B-A-C-B (verse-chorus-verse-interlude-chorus) result in an anticipation of repetition. Successful anticipation of movement and onset within a musical passage on behalf of the listener may lead to a positively valanced emotional response (Huron, 2007). Musical repetition also taxes cognitive resources to a lesser degree, since only a minimal amount of new information is parsed and organized in relation to each another.

Lempel and Ziv (1976) echo this sentiment by proposing a measure of complexity in relation to how many new 'substrings' are introduced through a sequence from left to right, such as in Arnold Schoenberg's *Erwartung* accounted for above.

Another measure and conceptualization of musical complexity is proposed by Povel and Essens (1985), with the relative ease or difficulty that a listener experiences when attempting to establish an 'internal clock' or tactus in relation to the music in order to symmetrically organize and perceptually group musical segments may be a marker for complexity. This conforms to the gestalt principle of simplicity. The presence of metrical ambiguity and numerous time-signature changes therefore lead to a significant increase in complexity-judgment. Swedish Experimental metal band Meshuggah for instance use large-scale hypermeasures and odd time-signatures (e.g. 28/16) as part of their repertoire, making beat-induction on behalf of the listener considerably difficult (Pieslak, 2007).

A final measure of complexity, one used in the current study, is that of melodic complexity (Eerola, 2003), which uses as a measure the extent to which a piece of music violates the listener's schematic expectations. As a result of such violation, listener anticipation and predictions fail. This conception of musical complexity bears resemblance to several of Pressing' (n.d) notions listed above, especially dynamic complexity with its resistance to gestalt-organization, as well as Povel and Essens (1985) notion of beat induction difficulty. The establishment of a *tactus* has already been shown to conform to metric-related schematic expectations by Huron (2007), as accounted for earlier, and thus music that violates these assumptions in favor of an irregular meter may be said to be complex in nature.

1.2.9 Cognitive and physiological effects of music.

Although several models of attention exist, three will receive particular attention due to their relevance to the task used in the current study. These are the complexity-arousal hypothesis based on Konecni's (1982) model of cognition, Hockey's (1997) compensatory control model, and the neuronal priming hypothesis.

1.2.9.1 Complexity-arousal hypothesis.

The effect of music on task performance has received considerable recent attention (Ünal, Steg, & Epstude, 2012), especially in regard to driving, possibly due to the prevalence of in-vehicle listening activities, whether via the radio or car audio systems that allow for CD's or, more recently, auxiliary MP3/smartphone connectivity. Here, research findings are divided between facilitative and deleterious effects.

For instance, North & Hargreaves (1999) measured performance on a computer driving race game while participants listened to arousing or unarousing music. The researchers' hypotheses were based on Konecni's (1982) model of music cognition, which posits that complex music is higher in arousal than non-complex music, and furthermore requires greater attentional processing space. This leads to a performance deficit when paired with a concurrent task. This hypothesis was confirmed in the study, with longer lap times in the presence of high arousal music relative to low arousal music.

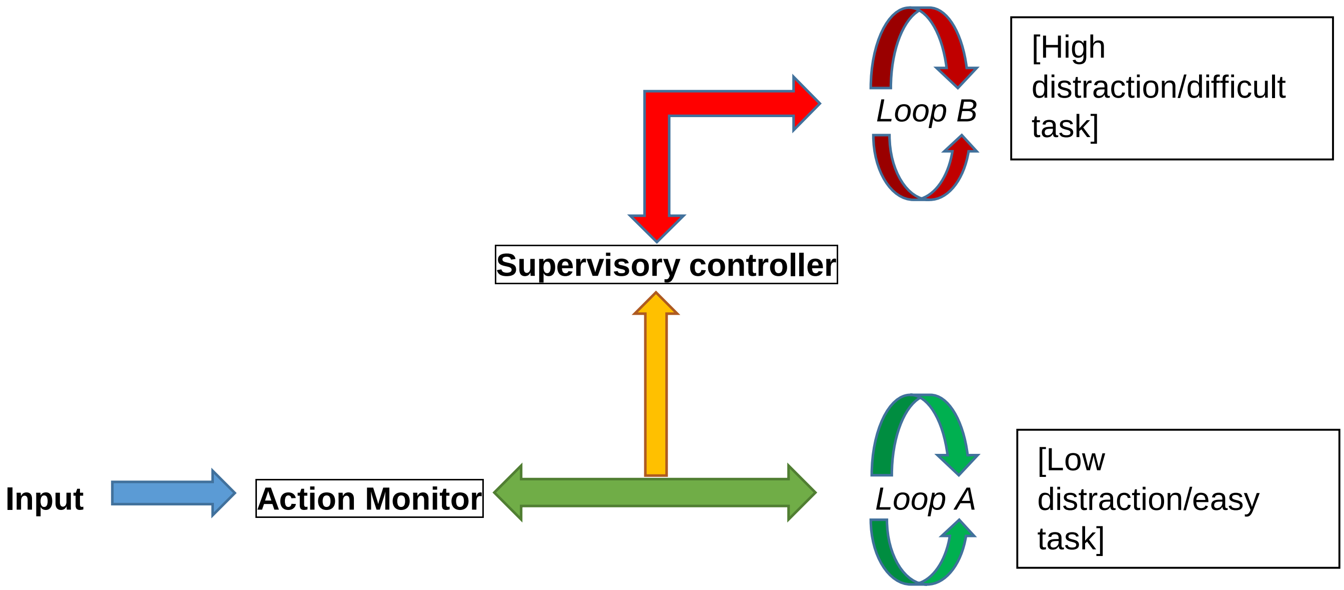
However, given that the study used a computer racing game, and not a driving simulator, it is unlikely that the driver-car dynamics possessed important degrees of realism. Also, familiarity with the computer game controls and track may have played a role in lap time outcomes, as may the lack of real consequences as a result of speeding (e.g. crashes).

Using a driving simulator instead, Brodsky (2002) sought to investigate the effects of tempo on driving performance, and found that driving speed and virtual traffic violations increased in tandem with music tempo. However, there were no significant differences between measures of heart rate and heart rate fluctuations between the high and low tempo music conditions. This seems to indicate that the high tempo music led to greater cognitive distraction effects, and not increased arousal *per se*, thus disentangling the affective and cognitive effects of music on performance.

1.2.9.2 Compensatory control model.

Figure 3 below illustrates Hockey's compensatory control model.

Figure 3 – Hockey's Compensatory control model



Performance is regulated by two negative feedback loops; in the lower level (loop A) an action monitor is responsible for "the 'automatic' control of skills under guidance of well-established performance goals", in other words non-effortful tasks. Thus, if a task requires minimal cognitive resources and effort, this loop is used to monitor task performance at a low set point. However, an increase in task difficulty/demands above a certain threshold triggers a compensatory shift to loop B at the higher level, also called the supervisory controller, where an active coping mode is maintained. This active coping mode is associated with "an elevated catecholamine response" (Hockey, 1997, p. 81), as well as "increased working memory or executive control" (Hockey, 1997, p. 81), and is often triggered under conditions of persistent external distraction. This is synonymous with the top-down mechanism proposed in other research (Marini, Chelazzi, & Maravita, 2013; Scalf, Torralbo, Tapia, & Beck, 2013). However, Hockey (1997) specifies a performance-cost tradeoff that occurs due to this shift to an active coping mode, resulting in increased anxiety, fatigue, and cortisol secretion.

Using the above model, Unal, Steg, & Epstude (2012) conducted a study aimed at examining the effects of loud music on driving performance and the role of mental effort as a mediator in this relationship. The results of the study indicate that while self-reported measures of mental load were greater during the loud music condition relative to the soft music condition, driver performances were not significantly different between the conditions, except in two sub-tasks in which the reaction time performances were significantly faster/better in the loud music condition, contrary to what would be predicted according to Konecni's (1982) model of music cognition as highlighted above in the research by North & Hargreaves (1999). Unal, Steg, & Epstude (2012) posit that this facilitative effect may be explained using Hockey's (1997) compensatory control model, which states that in conditions of high external distraction there is a compensatory switch in cognitive strategies to devote greater attentional resources to the salient attending task (i.e. control released to the supervisory controller in loop B), resulting in greater efficiency in task performance when compared to when there is no distraction. There is a price, however, to pay for this compensatory strategy and greater resource allocation, as prolonged activation led to physiological taxation.

1.2.9.3 Neuronal priming hypothesis.

Other potential facilitative mechanisms of music on cognitive performances have been documented, and range from facilitative effects on reading comprehension, arithmetic, as well as examination performances [for a review, see Rickard, Toukhsati, & Field (2005)]. In one of the most controversial studies conducted within music cognition, Rauscher, Shaw, & Ky (1995) demonstrated short-term improved performance scores on a measure of spatial reasoning among participants exposed to a Mozart sonata.

In the above study by Rauscher, Shaw, & Ky (1995), the Paper, Folding, & Cutting task (PF&C) was used to assess spatial-temporal processing among groups of participants exposed to 10 minutes of auditory stimuli in the form of different musical styles. This included a Mozart sonata, trance (dance) music, a modern minimalist piece by Phillip Glass, and a silent control. Test performance was then measured across several days, with results indicating significant and drastic short-term improvements in task performance for those participants exposed to Mozart's music. The authors reason that while repetitive music, such as the other styles/compositions present in the other experimental conditions, had no facilitative effect on spatial-temporal processing, complex music “primed the neuronal networks that would also be recruited to perform spatial-temporal mental manipulations” (Rickard, Toukhsati, & Field, 2005, p. 243). Although one subsequent study by Rideout & Laubach (1996) supports this inference, showing activation of proximal brain regions involved in music and spatial-temporal processing respectively, Hetland (2000) finds that such an hypothesis is particularly problematic because it violates two commonly held views in neuro-cognition, that of modularity and transfer.

Modularity refers to the theory of independent processing via “separate units dedicated to particular kinds of information” (Hetland, 2000, p. 105), and transfer to that of the difficulty encountered in transferring something learned in one context to performance in another context. Both of these are violated by the neuronal priming hypothesis, which, although not enough to disprove it, surely raises doubts as to its validity. While spun by the media as the “Mozart effect”, the study in fact never claimed that it was Mozart’s music itself that causes improvements on spatial reasoning, but rather the relative complexity of any piece of music, which “activates the right-hemisphere and hence spatial tasks” (Hetland, 2000, p. 136), specifically in regard to short-term spatial-temporal reasoning, not global intelligence (Rickard, Toukhsati, & Field, 2005, p. 237). However, follow up studies yielded mixed results, with some supporting the original findings, while others find no such facilitative effect (Hetland, 2000).

1.3 Research Questions and Hypotheses

Taking the above into consideration, the proposed study seeks to provide possible answers to the following questions: what effects may music with schematically incongruent, and thus complex structural properties have on attention, especially selective attention, when it is irrelevant or designated to the ‘background’ during the concurrent execution of a salient visual task? More fundamentally perhaps; does this effect differ significantly from that of music with simpler and schema-congruent properties?

Two competing explanatory models will thus be tested in the current study. If complex music results in a detriment in performance across all flanker types (i.e. slower reaction times), this will be consistent with Konecni's (1982) model of music cognition, which posits greater arousal and subsequent resource depletion when exposed to complex music, as in North & Hargreaves' (1999) study on the effect of highly-arousing music on lap time in a computer game task.

Alternatively, Hockey's (1997) compensatory control model predicts the possibility of faster reaction times for the complex music conditions, due to a compensatory shift to the supervisory controller (loop B), thus enhancing working memory and cognitive resources in order to complete the primary salient task. If the task is of a sufficient duration and intensity, significant tenseness and alertness scores should be yielded in the self-report scales for the complex music condition relative to the simple and control conditions. Although impossible to prove relative to the compensatory control model, the neuronal priming hypothesis will also predict this facilitative effect of complex music on task performance, albeit via a different theoretical mechanism.

Chapter Two

Method

2.1 Sampling.

The study made use of a convenience sample of students enrolled at The University of Witwatersrand’s School of Human and Community Development. Students registered in several psychology modules and courses were approached both in class and on the SAKAI student online platform. A participant information sheet was handed out in each case, containing finer details about the tasks and demands of the study. A demographic pre-test questionnaire was also handed out, as well as having been made available digitally via SurveyMonkey. In addition to answering questions pertaining to demographic variables and personal musical tastes, the pre-test questionnaire also contained timeslots for the computer-based task, allowing students to select the most convenient timeslot to attend if they agreed to participate in the study. There were two possible incentives for participation: first-year level psychology students in particular received course credits for partaking in the study, and all year-level students (including the first-year students) were entered into a raffle to win pairs of headphones at the conclusion of the study. The aforementioned procedures yielded a total of 27 participants, with a participant being defined as one who completed all three levels of the study – pretest questionnaire, post-test questionnaire, and the computer-based task.

2.2 Participants.

Registered psychology students at The University of the Witwatersrand across all year-levels volunteered to partake in the study. Although twenty seven participants took part in the experiment, five were excluded. More details regarding the exclusory process is outlined in the results section. The final sample comprised of twenty two individuals, with a mean age of 23. 46% were female (n=10), 50% male (n=11), while one participant did not reveal their sex. 55% of the participants were black (n=12), followed by 23% white (n=5), 9% coloured (n=2), and 5% Indian (n=1). The remaining 10% comprised of participants who selected the option to not reveal their race (n=1), and whom provided no answer to the question (n=1).

The majority of participants did not play a musical instrument (68%, n=15), while 27% of them did (n=6). One participant did not answer the question. Of those that played a musical instrument, only 2 participants played more than one. 46% of the sample (n=10) reported experiencing some form of chronic visual difficulty, 80% of which entailed shortsightedness (n=8), 10% farsightedness (n=1), and one participant claiming both. 50% of those with visual difficulties use glasses (n=5), and 10% contact lenses (n=1). The remaining 40% did not specify how they coped with their visual difficulty. Two participants also reported experiencing partial deafness (n=2).

2.3 Measures.

2.3.1 Pre-test questionnaire.

The pre-test questionnaire contained a total of 12 questions, divided into three subsections: questions 1-3 pertaining to demographic variables such as age, gender, and ethnicity, questions 4-7 to musical experiences and preferences, and questions 8-12 to visual/auditory disturbances or deficits (see appendix A). Questions regarding musical experience and history were also included.

A space was provided at the end of the questionnaire to construct a unique participant code using a combination of their initials and student number. This was done in order to guarantee confidentiality of all information yielded. Timeslots were appended to the questionnaire through an additional sheet of paper for the hard-copy, and a hyperlink to a separate SurveyMonkey collector on the digital version of the questionnaire. This ensured that responses on the questionnaire could not be linked with any participant/s attending a particular timeslot.

2.3.2 Post-test questionnaire.

This questionnaire (appendix B) was handed to participants after each of the three blocks in the computer based task, and was completed in pencil. The questions involved five point Likert scales (scored as 1 = not at all, 5 = very much so/completely) that provided an opportunity for the participants to rate both the task and the music (where applicable) in dimensions of difficulty, likeability, distractibility, and familiarity. Additionally, four items were provided at the end of the questionnaire aimed at capturing the self-reported affective states of the participants *in situ*. These items, in the form of semantic differential scales, included unpleasant-pleasant, tired-alert, tense-relaxed, and happy-sad. All three post-test questionnaires that followed the three experimental blocks were identical, with the exception of post-test questionnaire C, which did not include the three music-related items (likeability, familiarity and distractibility).

2.3.3 Attentional network task (ANT).

The Attentional Network Task (ANT) (Fan, McCandliss, Sommer, Raz, & Posner, 2002) was administered on computers running the E-Prime software (ver. 2.0.10.353). Reaction times and errors (the latter defined as the pressing of the incorrect mouse key in relation to the stimulus) are collected in the background and saved as an output file in the directory folder. The task contains four blocks, including one practice block and three experimental blocks. In the practice block, participants are first given explicit instructions of the protocols and demands of the task on-screen (these instructions are also read to the participants by the researcher). A practice block lasting two minutes then ensues when participants are ready to proceed. In the practice block, the reaction times and correctness of participant's mouse-button responses are given to the participants on-screen immediately after each trial. This feedback mechanism allows for the participants to infer whether they are correctly responding to the demands of the task and adjust accordingly. The three ensuing experimental blocks contain no feedback per trial, and are longer in duration than the practice trial (approximately 5 minutes each). A short break of approximately two minutes are given between blocks to limit cognitive fatigue, a possible confounder.

There were 288 trials in total for the task per participant, excluding the practice block, with a single trial being defined as an on-screen incident that required the participant's motor response in the form of a key-press. In other words, participants were required to respond to 288 stimuli in the form of a string of arrows in which the central arrow was the most salient. Each experiment block, and thus each music condition, included 96 trials. The trials contained an equal number of neutral, congruent, and incongruent flankers, such that 32 trials had neutral flankers, 32 congruent flankers, and 32 incongruent flankers.

Similarly, and overlapping with the flanker types, were 24 trials for each of the center, double, spatial (up and down), and no warning cue conditions respectively. The primary measure in the task is reaction time from appearance of the target stimulus to the pressing of the left or right mouse button.

2.4 Design & procedure.

A two-factor quasi-experimental repeated measures design was used, with partial counterbalancing employed to minimize carry-over and order effects. The two factors were flanker type, with three levels (neutral, congruent, incongruent), and music type (silent, simple, and complex music). Even though each trial block took about 5 minutes to complete, each track was cut to 10 minutes in order to prevent its premature ending while the task was still running.

For the silent music condition, a track that contained empty silence was used. For the simple music condition, the first movement of Franz Schubert's *Piano Sonata in A Minor, D 537* was used. This is a solo piano piece within the Romantic style, composed by Schubert in 1817 (IMSLP, 2015). For the complex atonal music condition, the first five movements of Arnold Schoenberg's *Suite per pianoforte op.25* was used. This suite was written in 1921. Silences/breaks between movements were removed using audio editing software in order to keep the auditory stimuli as seamless as possible.

Five computer terminals were used as testing-stations for the Attentional Network Task. The auditory stimuli were copied to the machines in the form of .wav files so as to enable playback through Windows Media Player. The files were renamed in the following manner; Schoenberg's [title] was renamed 'A.wav', Schubert's [title] was renamed 'B.wav', and a track containing silence to serve as the control condition was renamed 'C.wav'.

In order to mitigate possible order effects, each computer was allotted a specific and unique order of the musical/auditory stimuli in combination with the three experimental blocks. As a result, the music conditions were counterbalanced in the following pattern as illustrated in the table below.

Table 1 - Computer terminals and order of auditory stimuli

Computer Terminals	Order		
	Block 1	Block 2	Block 3
Terminal 1 (Lab 2)	A.wav	B.wav	C.wav
Terminal 2 (Lab 4)	A.wav	C.wav	B.wav
Terminal 3 (Lab 31)	C.wav	B.wav	A.wav
Terminal 4 (Lab 35)	C.wav	A.wav	B.wav
Terminal 5 (Lab 37)	B.wav	C.wav	A.wav

Playlists were then created for each terminal with the tracks in the orders as specified above. It is clear from the above that the counter-balancing procedure was not perfectly balanced, this due to limitations in hardware availability. In order to test whether reaction times under conditions of background music were confounded by its position in the order listed above, lab-specific reaction times for participants exposed to simple as well as complex music, respectively, early in the task (labs 1 and 2 for the complex music condition, lab 37 for the simple condition) were pooled and compared to the same for those exposed to the music late in the task (labs 31 and 37 for the complex and labs 4 and 35 for the simple music conditions).

An ANOVA revealed no significant differences between the reaction times based on position of the simple music condition, $F(1,12) = 0.337$, p = .572, as well as between positions of the complex music condition $F(1,15) = 1.410$, $p = .274$, thus ruling out position of the musical conditions as a possible confounder.

Prior to the commencement of the timeslot for the task, the E-Prime executable for the ANT task was run, and the window remained on screen. Upon entering the research laboratory, participants were seated at any of the available terminals, and the distance from eye-level to the center of the screen was measured using a tape-measure to ensure the standardized distance for the ANT task of 53 cm as outlined in Fan, McCandliss, Sommer, Raz, & Posner (2002). A consent form was handed out and participants were instructed to read and then indicate their acceptance of the terms of participation, or lack thereof, in the study. Their ability to withdraw at any time was then reiterated. Following the collection of the consent forms, participants were asked to enter their unique participant code into the relevant field on the screen. If they did not remember their unique participant code, a visual reminder of how to reconstruct the code was made available on the large whiteboard in front of the venue, and their attentions directed towards it. This was done so as to connect participant responses in the demographic and pre-test questionnaire with that of the ANT task and post-test questionnaires.

After entering their participant code, instructions for the task appeared, and the researcher proceeded to read these instructions to the participants as they followed them on their screen. Thereafter, participants initiated the first practice block by pressing the space bar when they were ready to do so. After completing the practice block, participants were queried as to whether they had any questions about the task and the rules. If they did, the researcher addressed and answered them. Once all the participants unanimously agreed that they are familiar with the rules and protocols, they were asked to place the pair of headphones that lay on the table over their ears. Two of the hotkey buttons on their keyboards had stickers placed on them to allow for easier reference and visual identification. They were instructed as to the purpose of these hotkeys, namely to press the hotkey with the silver star, which was the “play” hotkey and which initiated the first track on Windows Media Player in the background, and the hotkey with the yellow key, which was the “next” hotkey which played the next track in the playlist. They were instructed to only press the relevant buttons when told to do so by the researcher.

When ready, participants were told to first press the silver hotkey (play) and then the space bar to begin the first experimental block, and to raise their hand when the block ended (notated as such by an on-screen message proclaiming the end of the block). At the end of the block and the raising of all hands, participants were told to remove their headphones, place it on the table, and to fill out the first post-test questionnaire that lay on the pile of papers to their left. After all participants completed the first post-test questionnaire, they were instructed to press the yellow hotkey (next), to put the headphones back on, and then to once again press space bar to continue with block 2.

This cycle of events continued until the end of Block 3, after which all post-test questionnaires were collected and the ANT task window terminated. Participants were then thanked for their participation and left the research laboratory. These same set of standardized procedures continued for each timeslot for the duration of the data collection phase.

2.5 Data.

Response data from the ANT task were exported to MS Excel format using E-Merge, where it was then cleaned. This data cleaning procedure included the deletion of fields deemed unnecessary to the purpose of the study, such that only the reaction times and errors per trial, as well as the flanker types for each trial, remained. The music condition that each participant engaged in per block (derived from the order of the music conditions at the particular computer terminal at which the participant was seated) was also added to the spreadsheet. This allowed for the renaming of each block as one of the three music conditions; control, simple (Schubert), and complex (Schoenberg).

Since reaction times were given per trial only and not per music condition, mean reaction times per music condition, as a factor of flanker type, was calculated within SPSS using pivot tables. These mean reaction times were then used to construct a separate SPSS database for mean reaction times per participant for each of the flanker types. Responses on the pre-test and post-test questionnaires were coded and transcribed in MS Excel before being added to the ANT SPSS database.

2.6 Data analysis.

2.6.1 Reliability and outlier analyses.

Internal consistency of responses, using participants as ‘items’, were calculated using Cronbach’s alpha. Outlier analysis was also performed using two standard deviations above and below the mean RT per condition as criteria for the identification and deletion of outliers.

2.6.2 Descriptive statistics.

Mean RT for the control (silence), simple (Schubert), and complex (Schoenberg) musical conditions per flanker type (neutral, congruent, incongruent) were calculated and reported. Similarly, mean error rates for all the blocks and conditions were calculated.

2.6.3 Repeated measure ANOVAs.

Several repeated measure ANOVAs were conducted. In the first repeated measure ANOVA, musical condition served as one factor (with three levels: control, simple, complex), and flanker type as the other factor (also with three levels: neutral, congruent, incongruent). The dependent variable here was mean RT.

Since a statistically significant interaction was found between factors, an omnibus of one-way ANOVAS was performed per flanker type, conditional on the musical condition. This post-hoc procedure was necessary in order to infer the simple effects of the model, and the necessary significance level adjustment was made to compensate for familywise error.

Since error rates were highly negatively skewed and non-normal, in addition to containing a considerable amount of zeros (reflecting no errors made), assumptions for both parametric and non-parametric equivalents were violated. In order to account for the possible confounding of error rate, the two-way repeated measure ANOVA was re-run, but with data that included only those responses that were correct, as per the analyses in Benoni and Tsal (2010) and Fan et al. (2002) This allowed for a bypassing of the errors made by participants in order to better ascertain the role of music condition on mean reaction time.

A third repeated measure ANOVA was run for self-reported difficulty, pleasantness, alertness, tenseness, and happiness ratings, while paired sample T-tests for music likeability, familiarity, and distractibility were run, as per the post-test questionnaire responses.

2.6.4 Between-subject ANOVA.

A one-way between-subject ANOVA was conducted to evaluate the differences between reaction times of male and female participants across flanker types.

Chapter Three

Results

3.1 Reliability analysis.

A reliability analysis was conducted on the reaction time responses of participants across all flanker types to ensure internal consistency. Cronbach alpha values indicated high internal consistency for responses to the neutral ($\alpha = 0.97$), congruent ($\alpha = 0.98$), and incongruent ($\alpha = 0.96$) flankers.

3.2 Outlier analysis.

Outlier analysis was also conducted, using reaction time and errors two standard deviations above or below the mean for all trials. Using this method, four participants were removed from the analysis (see appendix C), with one further participant removed due to a violation of the task protocols during the testing procedure.

3.3 Gender comparisons.

Table 2 shows mean RT between gender groups (female vs. male). One participant did not declare their gender, reducing the sample size for this comparison in particular to 21.

Table 2 – Mean RT (milliseconds) across gender groups

Flankers	**Gender**	**N**	**Mean**	**Std. Deviation**
Neutral Flankers	Female	10	485	62.07
	Male	11	459	55.07
	Total	21	471	58.58
Congruent Flankers	Female	10	492	68.11
	Male	11	458	53.91
	Total	21	474	61.95
Incongruent	Female	10	596	79.03
	Male	11	538	68.43
	Total	21	566	77.61

Reaction times of males were faster under all flankers. However, a one way ANOVA determined that these differences were not statistically significant[3] for neutral, $F(1,19) = 1.063$, $p = .316$, congruent, $F(1,19) = 1.591$, $p = .222$, or incongruent flankers, $F(1,19) = 3.217$, $p = .089$.

3.4 Post-test questionnaire responses.

Table 3 contains the means for responses on the post-test questionnaires for each experimental block/music condition. For all rating questions, a 5-point Likert scale was used.

Table 3 – Post-test questionnaire responses

Rating Scale	**Music Condition**					
	Control		Simple (Schubert)		Complex (Schoenberg)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Task Difficulty	1.8	0.87	2.1	0.96	2.0	0.78
Pleasantness	3.9	1.23	4.0	1.03	4.0	1.15
Alertness	3.3	1.35	2.9	1.24	3.1	1.45
Tenseness	2.2	1.04	2.1	1.05	2.5	1.19
Happiness	3.7	1.22	3.8	1.12	3.6	1.14
Music Rating	-	-	3.3	1.56	3.0	1.28
Music Familiarity	-	-	3.0	1.43	2.6	1.47
Music Distraction	-	-	2.3	1.20	2.7	1.24

Repeated measure ANOVAS for self-reported difficulty ($p = .232$), pleasantness ($p = .800$), alertness ($p = .302$), tenseness ($p = .210$), and happiness ($p = .657$) ratings were not statistically different from each other. Paired sample T-tests for music likeability ($p =$

[3] Using the no-error trial data, reaction time differences across gender were also not statistically significant

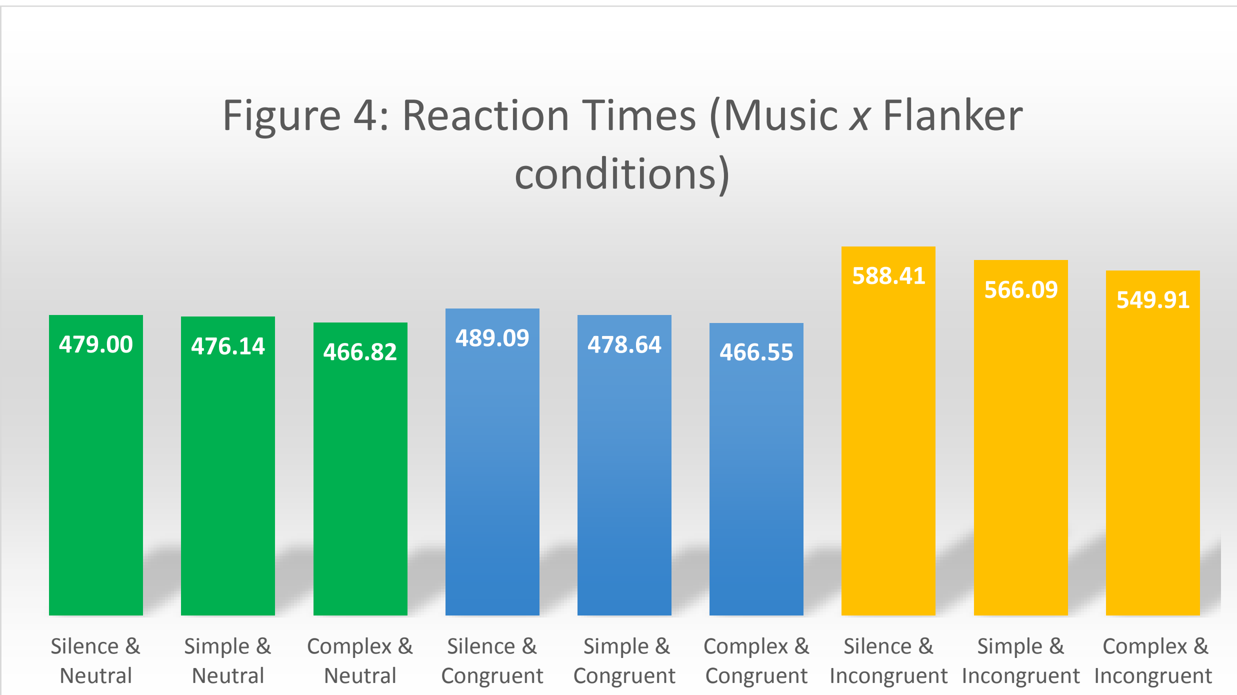
.383), familiarity (p = .072), and distractibility (p = .319) also revealed no statistically significant differences between them.

3.5 Reaction times and errors.

Table 4 shows a cross tabulation for mean reaction times across music and flanker conditions, and across all participants. These data is further illustrated in figure 4.

Table 4 – Reaction Times (milliseconds)

N = 22	**Neutral**	**SD**	**Congruent**	**SD**	**Incongruent**	**SD**	**TOTAL**	**SD**
Silence	479	(67)	489	(73)	588	(88)	*519*	*(73)*
Simple	476	(56)	479	(60)	566	(79)	*507*	*(63)*
Complex	467	(61)	467	(66)	550	(79)	*495*	*(68)*
TOTAL	*474*	*(58)*	*478*	*(63)*	*568*	*(76)*		



The descriptive statistics above indicate that across all flanker types, reaction times were fastest under the complex music condition (495 m/s), followed by the simple music condition (507 m/s), with the silent condition having the slowest reaction times (529 m/s). Table 5 shows the error percentages across all conditions. Unsurprisingly, incongruent flanker trials incurred the greatest amount of errors, given the difficulty of the task.

Table 5 – Error rates (%)

	Neutral	Congruent	Incongruent	TOTAL means (rows)
Control	1.13	0.14	5.12	*2.13*
Simple	0.43	0.14	5.26	*1.94*
Complex	0.42	0.85	6.4	*2.56*
TOTAL means (Columns)	*0.66*	*0.38*	*5.59*	

A two-way repeated measure ANOVA was run to determine whether these differences in RT were statistically significant. Mauchly's test of sphericity indicated that the assumption of sphericity was violated for the main effects of music condition, χ^2 (2) = 8.135, p = .017, for Flanker Type, χ^2 (2) = 21.663, p = .000, as well as for the interaction (music condition*flanker type), χ^2 (2) = 20.248, p = .017. Thus, the Greenhouse-Geisser corrections were used when interpreting the F scores.

The results indicate a significant main effect of music condition, F(1.499, 31.479) = 4.913, p = .021, η_p^2 = 0.19. Ignoring all other variables at this point, this tells us that reaction times were significantly different between the silent, simple, and complex music conditions.

Furthermore, there was a significant main effect of flanker type, F(1.204, 25.279) = 180.594, p < .001, η_p^2 = .90. This is an expected result, given that the flankers are intended to affect the task with variable difficulty, which then manifests in a significant effect on reaction times.

The interaction between music condition and flanker type also reached statistical significance, $F(2.543, 53.408)$, = 3.455, p = .029, η_p^2 = 0.14. In order to disentangle this interaction, it was necessary to calculate the simple effects using an omnibus of one-way ANOVA's per flanker type. Given that the sum of squares for the simple effect is equal to the sum of the sum of squares for the main effect plus the interaction (Keppel & Wickens, 2004), and that we give a significance level of 0.05 (α = 0.95) to each main effect and the interaction, the adjusted significance level for simple effects is 0.05*2, = 0.10. However, such unplanned multiple post-hoc tests hold the risk of considerable familywise error (Keppel & Wickens, 2004). Therefore, using the Bonferroni-Sidak correction, for an omnibus of three one-way ANOVA's, the adjusted familywise significance level (α_{FW}) is 0.10/3, = .033. This correction stipulates (1 - α) /k, where k is the number of tests being run.

3.5.1 ANOVA I: neutral flankers across all music conditions.

Mauchly's test of sphericity indicated no violation of its assumptions, with a non-significant result, χ^2 (2) = 3.577, p = .167. The test showed no significance difference between reaction time performances for neutral flankers, conditional on the type of music played to participants, $F(2, 42)$ = 1.833, p = .172, > α_{FW}, η_p^2 = 0.08.

3.5.2 ANOVA II: congruent flankers across all music conditions.

The assumptions of Mauchly's test of sphericity were not violated, with the result not reaching significance, χ^2 (2) = 5.352, p = .069. The test showed a significant difference between reaction time performances for congruent flankers, conditional on the type of music played to participants, $F(2, 42)$ = 3.904, p = .028, < α_{FW}, η_p^2 = .16. Pairwise comparisons indicate that the significance differences lie between the control music condition (silence) and the complex music condition (Schoenberg) (p = .020, < α_{FW}), but not between the simple music condition (Schubert) and the complex music condition (p = .049, > α_{FW}).

3.5.3 ANOVA III: Incongruent flankers across all music conditions.

The assumption of sphericity was violated using Mauchly's test of sphericity, χ^2 (2) = 9.771, *p* = .008. Thus the Greenhouse-Geisser corrections were used in interpreting the F scores. The test indicated a significant difference between reaction time performances for incongruent flankers, conditional on the type of music played to participants, *F*(1.442, 30.292) = 5.873, *p* = .013, < α_{FW}, η_p^2 = 0.013. Pairwise comparisons indicate the statistically significance differences lie between the control music condition and the complex music condition (*p* = .005), as well as between the simple music condition and the complex music condition (*p* = .031).

For error data, the skewness of the distributions indicate that the assumptions of normality were not met , thus a two-way repeated measure ANOVA could not be used to ascertain whether these differences were significant or not. The high number of zeros present (reflecting a lack of errors made by participants) also made it impossible to run a non-parametric alternative to the ANOVA, such as a Friedman's test, since a key assumption of this test is the presence of continuous data. While a Log_{10} transformation could remedy the presence of zeros, it would not solve the problem of considerable ties in the data, but only shift it up to 1.

In order to ascertain whether errors made played a role in the significant differences between music conditions in regard to mean RT, the two-way repeated measure ANOVA, with mean RT as the DV, was re-run, but this time using only participant responses that were correct. This follows on the practices of several research designs implementing reaction time tasks (Benoni & Tsal, 2010; Fan, McCandliss, Sommer, Raz, & Posner, 2002; Lavie, 2005). Thus, if a participant responded incorrectly to a trial, that trial was not included in the calculation of means. Table 6 below shows the number of trials that contained errors relative to those that did not.

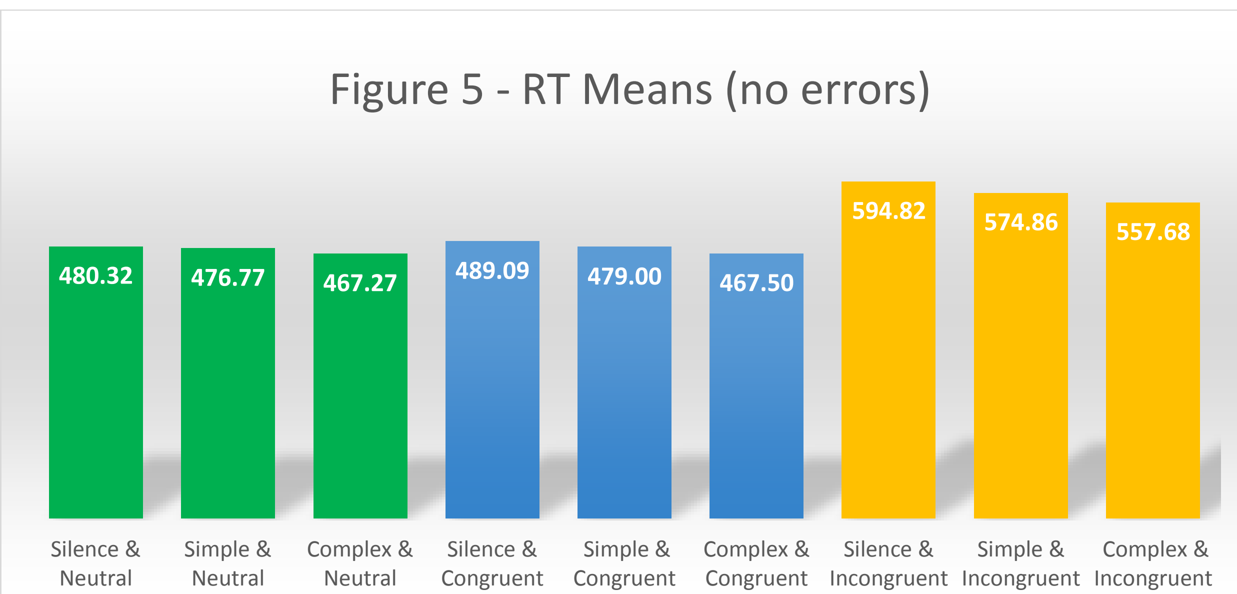
Table 6 – Breakdown of trial errors (the figures reflect number of trials summed across all participants)

	No-errors	**Errors**	**Total**
Neutral	1842	14	1856
Congruent	1847	9	1856
Incongruent	1745	111	1856

Table 7 shows the mean RT for no-error trials, accompanied by a visual representation in figure 5.

Table 7– Mean RT across no-error trials

N = 22	**Neutral**	**SD**	**Congruent**	**SD**	**Incongruent**	**SD**	**TOTAL**	**SD**
Silence	480	(68)	489	(73)	595	(87)	*521*	*(73)*
Simple	477	(58)	479	(60)	575	(80)	*510*	*(64)*
Complex	467	(61)	467	(66)	558	(77)	*497*	*(66)*
TOTAL	*475*	*(60)*	*478*	*(63)*	*576*	*(75)*		



Even after eliminating errors, the main effects of music on mean RT was found to be significant, *F*(1.487, 31.219), = 4.851, *p* = .023, η_p^2 = .19, as well as the main effect of flanker type on mean RT, *F*(1.148, 24.098), = 206.040, *p* < .001, η_p^2 = 0.91. However, the interaction between music and flanker conditions was not significant, *F*(2.629, 55.214), = 2.702, *p* = .061, η_p^2 = .11.

Pairwise comparisons on the main effect of music condition revealed a significant difference for reaction times between the control and complex conditions (*p* = .014), as well as between the simple and complex conditions (*p* = .018). Pairwise comparisons for the main effect of flanker type indication a significant difference between neutral and incongruent flankers (*p* = .000), and between congruent and incongruent flankers (*p* = .000).

Chapter Four

4.1 Discussion

While no significant differences were found between self-reported arousal, affective, and distraction rating questions across music conditions, the overall results indicate that task performance, as measured by reaction times, were significantly affected by the type of background music played. Using Cohen's (1988) recommendations for the interpretations of effect sizes, which were more recently supported by Bakeman (2005), this effect (η_p^2 = 0.19) may be regarded as medium. This effect size remained stable even when error-trials were excluded from analysis.

For the trial data inclusive of errors, reaction times were fastest across all flanker types when paired with complex background music, but the differences were statistically significant only for congruent flanker trials (between silent and complex music conditions), and for incongruent flanker trials (between silent and complex as well as between simple and complex music conditions).

When error trials were excluded from the analysis and means re-calculated based on correct responses only, the interaction between flanker type and music condition became non-significant. Pairwise comparisons indicated a significant difference in reaction times between the control and complex music conditions, as well as between the simple and complex music conditions. Since error-free trial data has been standardly used in past research on RT measures, the following discussion will focus primarily on these results.

While these faster reaction times under conditions of exposure to complex music supports previous findings attesting to the facilitative effects of music on task performance (Rauscher, Shaw, & Ky, 1995; Ünal, Steg, & Epstude, 2012), the lack of significant differences in self-reported arousal ratings between music conditions proposes a problem. These findings will now be evaluated in light of the two competing models, Konecni's (1982) model of music cognition, and Hockey's (1997) compensatory control model.

Konecni's (1982) model of music cognition predicted slower reaction times during the complex music conditions due to heightened arousal and the shared processing of both the salient visual task and the distracting background music. Despite the current study finding no significant differences in self-reported arousal ratings, the results are consistent with complex music having had a facilitative effect. Therefore, the findings of the current study do not extend or support Konecni's model as far as reaction time in a response-competition paradigm is concerned.

In Hockey's model, task performance management is handed over to the supervisory controller, a top-down mechanism, when a threshold is reached in regards to the difficulty encountered in successfully completing the primary salient task. This higher-order processing is associated to a temporary increase in working memory resources, possibly through an increase in catecholamine production and secretion (Hockey, 1997).

In the current study, the facilitative effect of complex background music on task performance may be due to the high distraction-potential of the atonal composition played to participants. The particular work of Schoenberg used in this study is highly complex, violating schematic expectations through a lack of a tonal center, wider than average melodic intervals, rhythmic irregularity, and unpredictable dynamic embellishments. This would have been flagged by the preattentive parsing monitor as salient, and the potential for distraction during task performance due to involuntary attention switching would have been high. Accordingly, the action monitor in Hockey's (1997) model (see figure 3 above), in order to provide optimal task performance, shifted control to the supervisory controller, a top-down mechanism, that provided the reserve/excess working memory capacity needed. This resulted in a focusing of selective attention on the primary salient visual task through reduced involuntary attention switching (Berti & Schroger, 2003), and thus ultimately faster reaction times. Self-reported task distraction ratings were indeed marginally higher for the complex music condition (M = 2.7, vs distraction rating of simple music condition with M = 2.3), yet this did not reach statistical significance. Contrarily, the simple music of Schubert did not engage the off-line syntactical parsing monitor, which scans and parses auditory stimuli using schematic- and dynamic-bound rules of expectations (Huron, 2007; Koelsch, Schroger, & Gunter, 2002), to the extent of Schoenberg's atonal composition due to minimal (if any) violations of that nature. Thus, it possessed less distraction-potential and did not detract from the primary salient visual task. Indeed, results indicate no statistically significant differences between task performance in the silent control condition and the simple music condition. In both these conditions, the task goals were easily managed by available cognitive resources, allowing processing at the lower set point level/loop A of Hockey's (1997) compensatory control model.

However, Hockey's (1997) model also predicts a performance-cost trade-off between optimal task performance and autonomic distress. Thus, responses to the self-reported affective and autonomic arousal scales for trials under condition of highly distracting and complex background music might have been expected to yield significantly higher tenseness ratings. Although tenseness ratings were indeed marginally higher for the complex background music condition (M = 2.5), this was not statistically significant in comparison with ratings for the silent control condition (M = 2.2) and simple music condition (M = 2.1).

There may be several explanations for this lack of significant differences in autonomic arousal ratings. Firstly, the use of a single question asking participants to rate how tense they feel may be criticized for lacking validity. A more thorough and aggregated measure of overall autonomic distress, especially one that included physiological indicators of arousal, may have been more appropriate and might have shown significant differences in autonomic arousal. Therefore, future research should combine the use of skin conductance and heart rate monitoring to better gauge any possible effect.

A second explanation may be that the task duration (less than five minutes for each block) was insufficient for the buildup, and therefore subjective awareness of, autonomic arousal on behalf of participants. Future research should therefore use experimental conditions of variable task-duration to ascertain if, and if so at what point, an increased task duration yields the significant autonomic arousal effects predicted by Hockey's (1997) compensatory control model as part of a performance-cost trade-off.

A third possibility, is that no performance-cost trade-off exists in regard to the facilitative effect of music on task performance. Using the neuronal-priming hypothesis (Rauscher, Shaw, & Ky, 1995), it may be argued that the results of the current study is equally explainable if one were to assume the priming of certain neuronal networks associated with monitoring and managing response-competition by the complex atonal composition used in the current study. Past research, however, has attempted testing the neuronal priming hypothesis in domains of cognition other than that of the original study (which tested spatial-temporal processing). These studies have largely yielded null results (for a review, see Hetland, 2000). Future research could therefore use brain imaging to explore whether there is activation of proximal brain regions involved in the passive listening to complex and/or atonal music, and response-competition respectively. Evidence of overlapping (or proximal) activation in/to the right ventrolateral prefrontal cortex, supplementary motor area, left parietal lobe, and/or left anterior parietal cortex, areas activated during response competition (Hazeltine, Poldrack, & Gabrieli, 2000), during such passive listening may provide tentative support for this hypothesis.

If the results of the current study are indeed consistent with Hockey's (1997) compensatory control model, it may help explain the disparate findings in past research on the role of cross-modal distraction in selective attention tasks. Specifically, whether auditory stimuli has facilitative or distracting effects may be dependent on which of these two loops are engaged. If the auditory distractor is potentially distracting yet fails to significantly attract automatic preattentive parsing processes, then task demands may be judged to be consistent with available cognitive resources at the lower set point of loop A. If, however, the auditory distraction engages the preattentive parsing process through predictive failures and parsing errors, a high distraction-potential exists which may detract from primary task performance. In this case, resource management is handed over to the supervisory controller, which increases available working memory, thus improving frontal-dependent task performance.

4.2 Limitations and Future Research

While some limitations have already been accounted for above, such as lack of physiological measures and the limits of self-reported accounts of arousal, there are several others worth noting. Firstly, the current study did not utilize an empirical method to measure extent of schematic expectancy violation. Given the choice of compositions and composers used in the study (Schubert and Schoenberg), it was assumed by the researcher, under advice from a professor of music, to be satisfactory exemplars of their respective musical conditions due to stylistic and compositional qualities. Future studies may possibly include pilot-testing of a selection of musical pieces, with experts providing a rating of complexity using as criteria the degree of expectancy violation present.

Furthermore, the use of classical music may limit the generalizability of the findings, as complex music from several other genres (such as that of free jazz and experimental metal) were not used despite their greater popularity than the purely atonal works used herein. Future research could therefore use several exemplars of complex music across disparate genres in order to isolate whether the effects of complex music on task performance is genre-dependent or not. Although existing works of both Schoenberg and Schubert, respectively, were used in the current study in order to maintain ecological validity, as opposed to researcher-generated or -composed music, the problem of possible confounding effects may have been present (such as the key, mode, or timbre of the Schubert piece). These factors were, however, attempted to be controlled for via the inclusion of self-reported questions in the current study.

Future research could also investigate the effects of complex and atonal music on other cognitive tasks, such as simulated driving tasks and response inhibition (stop-start) tasks. This may show whether the significant facilitative effects found in the current study exist only in response-competition tasks, whether it generalizes to other pre-frontal oriented cognitive tasks, and whether there exists thresholds and limitations to this effect.

Several study-specific limitations were also encountered. Occasional power disruptions to the research laboratory limited the time available to conduct the study, and the instability of the runtime version of E-Prime (which crashed if the window was minimized as well as if one switched to another active window) required the purchase of keyboards with special hotkeys that allowed a switching of tracks on windows media player without minimizing the E-prime window. However, availability of these keyboards was limited, further reducing the number of available computer terminals and therefore reducing the ultimate sample size.

4.3 Conclusion

The current study sought to investigate the effects of background music on task performance in a response-competition paradigm. In doing so, competing models of cross-modal cognition were tested in a quasi-experimental research design, with participant's response times in the attentional network task (ANT) used to infer whether music had a facilitative or distracting effect on task performance. The results were consistent with Hockey's (1997) compensatory control model, which predicted faster reaction times during concurrent exposure to complex music due to the activation of the supervisory controller, a top-down mechanism, which allotted greater working memory resources to the primary task. While the model also entailed a performance-cost tradeoff in the form of physiological distress, self-reported measures of affective and physiological states yielded no statistically significant differences between music conditions. Future research should therefore expand on the current findings by implementing brain imaging and/or other physiological measures of distress, such as skin conductance and heart rate monitoring.

References

Arkes, H., Rettig, L., & Scourgale, J. (1986). The Effect of Concurrent Task Complexity and Musical Experience on Preference for Simple and Complex Music. *Psychomusicology, 6*, 51-60.

Bakeman, R. (2005). Recommended effect size statistics for repeated measures designs. *Behavior Research Methods, 37*(3), 379-384.

Benoni, H., & Tsal, Y. (2010). Where have we gone wrong? Perceptual load does not affect selective attention. *Vision Research, 50*, 1292-1298.

Berti, S., & Schroger, E. (2003). Working memory controls involuntary attention switching: evidence from an auditory distraction paradigm. *European Journal of Neuroscience, 17*, 1119-1122.

Bharucha, J. (1996). Melodic anchoring. *Music Perception, 13*, 383-400.

Boltz, M. (1993). The generation of temporal and melodic expectancies during musical listening. *Perception and Psychophysics, 53*, 585-600.

Bonnel, A.-M., & Hafter, E. (1998). Divided attention between simultaneous auditory and visual signals. *Perception & Psychophysics, 60*(2), 179-190.

Brand-D' Abrescia, M., & Lavie, N. (2008). Task coordination between and within sensory modalities: Effects on distraction. *Perception & Psychophysics, 70*(3), 508-515. doi:10.3758/PP.70.3.508

Broadbent, D. (1958). *Perception and communication.* London: Pergamon.

Brodsky, W. (2002). The effects of music tempo on simulated driving performance and vehicular control. *Transportation Research Part F*, 219-241.

Buetti, S., Lleras, A., & Moore, C. (2014). The flanker effect does not reflect the processing of "task-irrelevant" stimuli: Evidence from inattentional blindness. *Psychonomic Bulletin & Review*. doi:10.3758/s13423-014-0602-9

Chan, M., Esteve, D., Escriba, C., & Campo, E. (2008). A review of smart homes - Present state and future challenges. *Computer Methods and Programs in Biomedicine, 91*, 55-81.

Cherry, C. (1953). Some Experiments on the Recognition of Speech, with One and with Two Ears. *The Journal of the Acoustical Society of America, 25*(5), 975-979.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* New Jersey: Erlbaum.

De Fockert, J., & Leiser, J. (2014). Better target detection in the presence of collinear flankers under high working memory load. *Frontiers in Human Neuroscience, 8*, 1-6.

Deutsch, J., & Deutsch, D. (1963). Attention: Some theoretical considerations. *Psychological Review, 70*, 80-90.

Driver, J. (2001). A selective review of selective attention research from the past century. *British Journal of Psychology, 92*, 53-78.

Eerola, T. (2003). *The Dynamics of Musical Expectancy.* Jyväskylä: University of Jyväskylä.

Eerola, T., Louhivuori, J., & Lebake, E. (2009). Expectancy in Sami Yoiks revisited: The role of data-driven and schema-driven knowledge in the formation of melodic expectations. *Musicae Scientiae, 13*(2), 231-272.

Fan, J., McCandliss, B., Sommer, T., Raz, A., & Posner, M. (2002). Testing the Efficiency and Independence of Attentional Networks. *Journal of Cognitive Neuroscience*, 340-347.

Forster, S., & Lavie, N. (2008). Failures to Ignore Entirely Irrelevant Distractors: The Role of Load. *Journal of Experimental Psychology: Applied, 14*(1), 73-83. doi:10.1037/1076-898X.14.1.73

Forster, S., & Lavie, N. (2011). Entirely irrelevant distractors can capture and captivate attention. *Psychonomic Bulletin & Review, 18*, 1064-1070. doi:10.3758/s13423-011-0172-z

Friedheim, P. (1966, Spring). Rhythmic Structure in Schoenberg's Atonal Compositions. *Journal of the American Musicological Society, 19*(1), 59-72.

Furnham, A., & Allass, K. (1999). The Influence of Musical Distraction of Varying Complexity on the Cognitive Performance of Extroverts and Introverts. *European Journal of Personality, 13*, 27-38.

Hahn, B., Wolkenberg, F., Ross, T., Myers, C., Heishman, S., Stein, D., Karup, P., Stein, E. (2008). Divided versus selective attention: evidence for common processing mechanisms. *Brain Research*, 137-146.

Hahne, A., & Friederici, A. D. (1999). Electrophysiological Evidence for Two Steps in Syntactic Analysis: Early Automatic and Late Controlled Processes. *Journal of Cognitive Neuroscience, 11*(2), 194-205.

Hazeltine, E., Poldrack, R., & Gabrieli, J. (2000). Neural activation during response competition. *Journal of Cognitive Neuroscience, 12*(2), 118-129.

Hetland, L. (2000). Listening to Music Enhances Spatial-Temporal Reasoning: Evidence for the "Mozart Effect". *Journal of Aesthetic Education, 34*, 105-108.

Hockey, R. (1997). Compensatory control in the regulation of human performance under stress and high workload: A cognitive-energetical framework. *Biological Psychology, 45*, 73-93.

Huron, D. (2007). *Sweet Anticipation: Music and the psychology of expectation.* Massachusetts: The MIT Press.

IMSLP. (2015). *Piano Sonata No.4, D.537 (Schubert, Franz)*. Retrieved from International Music Score Library Project: http://imslp.org/wiki/Piano_Sonata_No.4,_D.537_(Schubert,_Franz)

Jones, M., Moynihan, H., MacKenzie, N., & Puente, J. (2002). Temporal aspects of stimulus-driven attending in dynamic arrays. *Psychological Science, 13*(4), 313-319.

Keppel, G., & Wickens, T. (2004). *Design and Analysis: A Researcher's Handbook* (4th ed.). New Jersey: Pearson Education.

Kibler, J. (2011). Cognitive Schemas. *Encyclopedia of Child Behavior and Development*, 382.

King, J. W., & Kutas, M. (1995). Who Did What and When? Using Word- and Clause-Level ERPs to Monitor Working Memory Usage in Reading. *Journal of Cognitive Neuroscience, 7*(3), 376-395.

Koelsch, S., Gunter, T., Schroger, E., Tervaniemi, M., Sammler, D., & Friederici, A. (2001). Differentiating ERAN and MMN: An ERP study. *Neurophysiology, Basic and Clinical, 12*(7), 1385-1389.

Koelsch, S., Maess, B., & Friederici, A. (2000). Musical syntax is processed in the area of Broca: An MEG study. *Neuroimage, 11*(5), S56.

Koelsch, S., Schroger, E., & Gunter, T. (2002). Music matters: Preattentive musicality of the human brain. *Psychophysiology, 39*, 38-48. doi:10.1017.S004857720102011X

Konecni, V. (1982). Social interaction and musical preference. In D. Deutsch, *The psychology of music.* New York: Academic Press.

Koopman, H., Sportiche, D., & Stabler, E. (2003). *An Introduction to Syntactic Analysis and Theory.* Retrieved from ACLA Department of Linguistics: http://www.linguistics.ucla.edu/people/stabler/isat.pdf

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Journal of Experimental Psychology - Human Perception and Performance, 21*, 451-468.

Lavie, N. (2005). Distracted and confused?: Selective attention under load. *Trends in Cognitive Science, 9*(2), 75-82.

Lavie, N. (2010). Attention, Distraction, and Cognitive Control Under Load. *Current Directions in Psychological Science, 19*(3), 143-148.

Lee, K., & Choo, H. (2013). A critical review of selective attention: an interdisciplinary perspective. *Artifical Intelligence Review, 40*, 27-50.

Lempel, A., & Ziv, J. (1976). On the complexity of finite sequences. *IEEE Transactions on Information Theory, 2*(1), 75-81.

Lindsay, P., Taylor, M., & Forbes, S. (1968). Attention and multidimensional discrimination. *Perception & Psychophysics, 4*(2), 113-117.

Loui, P., Grent-'t-Jong, T., Torpey, D., & Woldorff, M. (2005). Effects of attention on the neural processing of harmonic syntax in Western music. *Cognitive Brain Research, 25*, 678-687.

Luo, S., Jin, J., & Li, J. (2009, April). A Smart Fridge with an Ability to Enhance Health and Enable Better Nutrition. *International Journal of Multimedia and Ubiquitous Engineering, 4*(2), 69-80.

Marini, F., Chelazzi, L., & Maravita, A. (2013). The Costly Filtering of Potential Distraction: Evidence for a Supramodal Mechanism. *Journal of Experimental Psychology, 142*(3), 906.

Narmour, E. (1991). *The Analysis and Cognition of Basic Melodic Structures: The Implication-Realization Model.* Chicago: University of Chicago Press.

North, A., & Hargreaves, D. (1999). Music and driving game performance. *Scandinavian Journal of Psychology, 40*, 285-292.

Palmer, C., & Krumhansl, C. (1990). Mental representation for musical meter. *Journal of Experimental Psychology: Human Perception and Performance, 16*, 728-741.

Pieslak, J. (2007). Re-casting Metal: Rhythm and Meter in the Music of Meshuggah. *Music Theory Spectrum, 29*(2), 219-246.

Povel, D., & Essens, P. (1985). Perception of temporal patterns. *Music Perception, 2*, 411-441.

Pressing, J. (n.d.). *Cognitive complexity and the structure of musical patterns*. Retrieved from UC San Diego Department of Music : http://musicweb.ucsd.edu/~sdubnov/mu206/cogcomplex-music.pdf

Rauscher, F., Shaw, G., & Ky, K. (1995). Listening to Mozart enahcnes spatial-temporal reasoning: Towards a neurophysiological basis. *Neuroscience Letters, 185*, 44-47.

Rickard, N., Toukhsati, S., & Field, S. (2005). The effect of music on cognitive performance: insight from neurobiological and animal studies. *Behav Cogn Neurosci Rev, 4*(4), 235-261.

Rideout, B., & Laubach, C. (1996). EG correlates of enhanced spatial performance following exposure to music. *Perceptual Motor Skills, 82*(2), 437-432.

Scalf, P., Torralbo, A., Tapia, E., & Beck, D. (2013, May). Competition explains limited attention and perceptual resources: implications for perceptual load and dilution theories. *Frontiers in Psychology, 4*, 1-9. doi:10.3389/fpsyg.2013.00243

Schellenberg, E. (1996). Expectancy in melody: tests of the implication-realization model. *Cognition, 58*, 75-125.

Shmulevich, I., & Povel, D.J. (2000). Complexity measures of musical rhythms. In P. Desain, & L. Windsor, *Rhythm perception and production* (pp. 239-244). Lisse: Swets & Zeitlinger.

Taylor, M., Lindsay, P., & Forbes, S. (1967). Quantification of Shared Capacity Processing in Auditory and Visual Discrimination. *Acta Psychologica, 27*, 223-229.

Treisman, A. (1969). Strategies and models of selective attention. *Psychological Review, 76*, 282-299.

Ünal, A., Steg, L., & Epstude, K. (2012). The influence of music on mental effort and driving performance. *Accident Analysis and Prevention*, 271-278.

Villarreal, E. A., Brattico, E., Leino, S., Ostergaard, L., & Vuust, P. (2011). Distinct neural responses to chord violations: A multiple source analysis study. *Brain Research, 1389*, 103-114.

von Hippel, P. (2002). Melodic-expectation rules as learned heuristics. In C. Stevens, D. Burnham, G. McPherson, E. Schubert, & J. Renwick, *Proceedings of the 7th International Conference on Music Perception and Cognition.* Adelaide: Causal Productions.

Appendices

APPENDIX A: Pre-test Questionnaire

Section A: Biographical Information:

(1) Age:______

(2) Gender: (*mark the appropriate column with an 'x'*)

MALE	
FEMALE	

(3) What ethnicity would you classify yourself under? (*mark the appropriate column with an 'x')*

AFRICAN	
ASIAN	
CAUCASIAN	
COLOURED	
INDIAN	
OTHER (specify below) ______________________	

Section B: Musical History

(1) Do you play any musical instruments (this includes singing)? – *mark the appropriate column with an 'x'*

Yes	
No	

(a) If yes, please list the instrument(s) you play:

____

____

____

(b) How many years have you been playing these instruments? (if more than one, please answer for each of the instruments stated above in *1a*)

____

____

____

____

____

(2) Have you had any formal training for any of the instruments listed in question 1.a (*mark the appropriate column with an 'x'*)?

Yes	
No	

(a) How many years of formal training have you had (if more than one instrument, please answer for each of the instruments stated above in *1a*)?

____

____

____

(3) Please indicate your personal preferences in regard to the following genres (*mark with an x*):

	I don't like it	**It's okay**	**I like it**	**I love it**
Jazz				
Classical				
Kwaito				
Rock/Metal				
Hip-Hop/Rap				
Pop				
House				
Electronic/Trance				
Gospel				
Other (specify below) ______________________				

Section C: Vision and Hearing

(1) Do you experience any visual difficulties for which you require aid in the form of glasses/spectacles/contact lenses?

Yes	
No	

(2) Are you near- or farsighted?

Yes	
No	

(3) When seated in front of a computer, do you experience any difficulties reading text or deciphering images on the computer screen?

Yes	
No	

(4) Have you been diagnosed with, or suspect that you may have, colour blindness?

Yes	
No	

(5) Have you ever experienced, or suspect that you may have experienced, an epileptic seizure?

Yes	
No	

(6) Have you ever experienced a headache shortly after staring at a screen that contained bright flashing lights?

Yes	
No	

(7) Do you experience any hearing difficulties?

Yes	
No	

APPENDIX B: Post-test questionnaire

(1) On a scale of 1-5 (with '1' being *very easy* and '5' being *very difficult*) how would you rate the visual task just completed? (Please circle the appropriate number below)

1	2	3	4	5

(2) On a scale of 1-5 (with '1' being *disliked* and '5' being *liked*) how would you rate the music that was played during the course of the task? (Please circle the appropriate number below)

1	2	3	4	5

(3) On a scale of 1-5 (with '1' being *not familiar at all* and '5' being *very familiar*) how acquainted are you with the music that was played during the course of the task? (Please circle the appropriate number below

1	2	3	4	5

(4) On a scale of 1-5 (with '1' being *not at all* and '5' being *very distracting*) how distracting did you find the visual task combined with the music played? (Please circle the appropriate number below

1	2	3	4	5

(5) Please read the descriptors at the ends of each scale and then check the box along the scale that best describes how you feel right now.

Unpleasant						Pleasant
Tired						Alert
Tense						Relaxed
Happy						Sad

APPENDIX C – Outliers

Reaction times						
				Cut-off range		
Participant	**Music & Flanker**	**Mean**	**Std. Deviation**	**2STD Below**	**2STD Above**	**Participant's Score**
Outlier 1	Simple & Neutral	487.58	69.54	348.50	626.66	*636*
Outlier 1	Simple & Congruent	491.35	81.69	327.96	654.73	*681*
Outlier 1	Simple & Incongruent	579.96	105.87	368.21	791.71	*866*
Outlier 2	Simple & Neutral	487.58	69.54	348.50	626.66	*648*
Outlier 2	Simple & Congruent	491.35	81.69	327.96	654.73	*665*
Outlier 3	Complex & Congruent	468.27	103.93	260.40	676.14	*121*
Outlier 3	Complex & Incongruent	547.77	111.27	325.24	770.30	*196*
Outlier 3	Complex & Neutral	468.27	101.87	264.53	672.01	*111*
Outlier 3	Control & Congruent	488.12	105.95	276.21	700.02	*143*
Outlier 3	Control & Incongruent	584.50	126.03	332.45	836.55	*172*
Outlier 3	Control & Neutral	476.42	89.19	298.05	654.79	*185*
Errors						
				Cut-off range		
Participant	**Music & Flanker**	**Mean**	**Std. Deviation**	**2STD Below**	**2STD Above**	**Participant's Score**
Outlier 3	Complex & Congruent	3.84	15.24	-26.63	34.31	*78*
Outlier 3	Complex & Incongruent	12.28	22.26	-32.23	56.80	*97*
Outlier 3	Complex & Neutral	3.72	15.87	-28.02	35.47	*81*
Outlier 3	Control & Congruent	3.24	15.27	-27.30	33.78	*78*
Outlier 3	Control & Neutral	3.84	14.61	-25.38	33.07	*75*
Outlier 3	Control and Incongruent	10.61	21.30	-31.99	53.21	*91*
Outlier 3	Simple & Congruent	2.52	12.25	-21.97	27.02	*62*
Outlier 3	Simple & Incongruent	10.58	19.99	-29.39	50.56	*81*
Outlier 3	Simple & Neutral	2.76	10.47	-18.17	23.69	*53*
Outlier 4	Simple & Incongruent	10.58	19.99	-29.39	50.56	*72*
Outlier 4	Complex & Incongruent	12.28	22.26	-32.23	56.80	*66*